WEDGEWIRE SCREEN SITE-SPECIFIC STUDY ENGINEERING EVALUATION

GSP SCHILLER LLC – SCHILLER STATION PORTSMOUTH, NEW HAMPSHIRE

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EXECUTIVE SUMMARY

In order to evaluate the effectiveness and availability of wedgewire screens at GSP Schiller LLC's Schiller Station, a Site-Specific Study was conducted consistent with the compliance condition specified in Part I.A.11.a.1 of National Pollutant Discharge Elimination System Permit No. NH0001473. Pilot wedgewire screens with 3.0 millimeter (mm) and 0.8 mm openings were simultaneously tested in the Piscataqua River in the vicinity of Schiller Station. The Wedgewire Screen Site-Specific Study had an extended test period, spanning from late 2018 to late 2019. The study observed and recorded the performance and conditions of the pilot wedgewire screens in comparison to the baseline control of the Screen House #2 withdrawal through the existing traveling water screens.

The enclosed engineering technical report was compiled throughout the test period. The main body of the report details the design, installation, and engineering analyses completed in support of the Wedgewire Screen Site-Specific Study at Schiller Station, as well as the results and conclusions of the study. The main body of the report is followed by attachments providing the equipment specifications and design drawings. Addendums to this report detailing the events and changes that occurred during the testing period are provided following the attachments. The physical conditions of the pilot wedgewire screens and equipment are analyzed in the addendums, providing an evaluation of the fouling and damage that occurred throughout the testing period. Finally, a technical availability summary concludes the results of the Wedgewire Screen Site-Specific Study at Schiller Station.

At the conclusion of the testing period, the total proportion of damaged surface area on each wedgewire screen was approximately 16% and 19% for the 3.0 mm and 0.8 mm screens, respectively. This lowered the effectiveness of the screens, due to the large openings, estimated to be 2.5 inches (in.) wide and 3.5 in. wide for the 3.0 mm screens and 0.8 mm screens, respectively. The damage on each pilot wedgewire screen was initially concentrated on the bottom regions of the screens nearest the central riser and was observed to increase rapidly outward. At the time of final inspection, the percentage of the withdrawn flow rate bypassing the screen through the damaged openings was estimated to be 23% and 45% for the 3.0 mm and 0.8 mm screens, respectively. Due to the excessive screen bypass, the samples taken following the damage were not considered when evaluating exclusionary performance. This bypass flow rate percentage is an estimate for a completely clean screen and would increase further under clogged conditions.

The peak total proportion of clogged surface area observed on the pilot wedgewire screens was 21% and 36% for the 3.0 mm and 0.8 mm screens, respectively. The fouling on each screen was distributed with no apparent pattern and was independent of the amount and location of damage. Fouling and damage are each considered to be abnormal operating conditions for cylindrical wedgewire screens. In a practical implementation of wedgewire screens, these conditions would be uncommon and would not be anticipated to be significant within the first year of operation. Based on the results of the site-specific study, it is unknown if there would be any relationship between fouling and damage at Schiller Station. Fouling and damage in combination result in increased through slot velocity and head loss, and decreased exclusion efficiency.

Based on the results of this site-specific study, significant damage and fouling of the screens is considered likely to occur on a full-scale wedgewire screen if installed at Schiller Station. The effectiveness, reliability and durability of a full-scale wedgewire screen would be uncertain given the rapid development of damage and fouling observed on both pilot wedgewire screens. The results of this site-specific study found a statistically significant number of aquatic organisms with bounding dimensions larger than the 0.8 mm wedgewire screen mesh were entrained. Excessively high ambient current velocities may have caused the entrainment of fish eggs or larvae of larger size than the screen opening due to extrusion effects.

The varied issues demonstrated during the site-specific study are indicative that similar issues would impact a full-scale wedgewire screen system due to an increase in the number of screens and an increase in affected surface area. A limited technology lifespan as brief as one year, as observed during the site-specific study, would result in frequent periods of ineffective use of the technology. Additionally, cleaning of the fouled wedgewire screens, dredging in the vicinity of the intake, repair of damaged wedgewire screens, replacement of wedgewire screens deemed beyond repair, and maintenance of new balance-of-plant equipment would make implementation an ongoing, expensive endeavor. Accordingly, the implementation of full-scale wedgewire screens at Schiller Station is considered a difficult, costly and imprudent measure which would not provide reliable, year-round operation.

1.0 BACKGROUND

This document provides the installation instructions, equipment specifications, post-testing conditions, and conclusions of the Wedgewire Screen Site-Specific Study at Schiller Station, owned and operated by GSP Schiller LLC (GSP). As described in the "Wedgewire Screen Site-Specific Study Scope Description", submitted in July 2018 (Ref. 6.5), further design efforts and testing occurred at Schiller Station through 2019 in compliance with National Pollutant Discharge Elimination System (NPDES) Permit No. NH0001473. Attached to this document are specifications for performance dependent components (Attachment 1), the bill of materials (Attachment 2), specified pump internals coated for corrosive protection (Attachment 3), system design drawings (Attachment 4), civil engineering calculations (Attachment 5), change of equipment specification (Addendum A), abnormal operating event report (Addendum B), damage and fouling reports (Addenda C through E), and conclusions based on the results of the site-specific study (Technical Availability Summary).

2.0 INSTALLATION INSTRUCTIONS

2.1 PILOT WEDGEWIRE SCREENS

Prior to the installation of the pilot wedgewire screens, preliminary water velocity and bathymetry studies were performed via vessel-mounted Acoustic Doppler Current Profilers (ADCPs) and a standalone ADCP deployment in the Piscataqua River. The data collected from the ADCPs was used to determine the predominant river flow direction and guide the alignment of the longitudinal axis of the screens.

The pilot wedgewire screen system was designed to test the availability of half cylinder wedgewire screens at Schiller Station. Half cylinder wedgewire screens were selected using a similar methodology as used at Merrimack Station (Reference 6.14). The pilot wedgewire screens and supporting systems were designed, constructed, and installed to similar specifications, aside from the key differences described in the following two paragraphs. Each pilot wedgewire screen was a Johnson Intake Screens Model T-12HC high capacity intake cylindrical wedgewire screen with dimensions: 12.62 in. outside diameter and 13 in. centerline to flange height. The wedgewire mesh of each screen was constructed of 69 wire (0.071 in. diameter). Each screen was constructed of biogrowth resistant Z-Alloy to reduce the amount of surface area clogged by fouling. Each screen had cone style closures to deflect waterborne debris and aquatic organisms away from the screen. The following differences are considered negligible, controlled details and are not believed to have influenced the results of the site-specific study. Differences in screen performance are attributed to the difference in wedgewire screen slot width.

The north 0.8 mm screen had an effective screen length of seven inches and overall length of 31.8 in. The 0.8 mm screen was procured from the vendor without the tripod support legs. The 1-¼-in. stainless steel (SS) legs were fabricated and assembled as shown on GSPL-00001-SK-001, which includes turning down one end of each SS leg and welding the other end at an angle to a SS baseplate. The length of each leg was cut such that only one SS base plate was needed at the footing, allowing clearance for the short radius elbow atop the concrete pad. A coupler was fabricated according to the detail on GSPL-00001-SK-001. Non-conductive sleeves were required for the interfaces between the coupler, through bolts, etc. and the Z-Alloy portions of the screen.

The assembled screen with tripod legs and base plate was mounted to the pre-cast concrete pad, as shown on the drawing, using the anchor bolts and identified embedment depth.

The south 3.0 mm screen had an effective screen length of six inches and overall length of 35 in. The 3.0 mm screen and tripod legs were repurposed from a prior Site-Specific Study at GSP's Merrimack Station. The screen assembly was inspected to be in suitable physical condition for reuse. The 3.0 mm screen tripod support SS legs, included with screen, were attached with the vendor provided coupler equipment. Drawing GSPL-00001-SK-002, illustrates dimensions of the fabricated coupler. The screen was attached to the concrete pad using anchor bolts. Through holes were drilled in each base plate to accommodate the anchor bolts. An analysis of the structural components of the screen supports are found in Section 3.4.

The pilot wedgewire screens were installed on relatively level ground. The distance from the base of the concrete pad to the centerline of the screens was measured to be 39.75 in., which matches the height of a full scale half cylinder wedgewire screen installation. The screens were oriented such that the long axis of the screens was aligned with the predominant direction of the river current based on the data gathered from the preliminary ADCP studies.

As shown by the analysis provided in Section 3.1, the pilot wedgewire screens were at a suitable location at the river bottom, in the vicinity of where a full-scale screen would be installed. The selected location of the pilot wedgewire screens installation was much further into the river than initially anticipated due to the river current profile observed during the preliminary ADCP studies. The relocation of the pilot wedgewire screens resulted in a brief delay in the completion of installation.

The screens included a 90° short radius elbow welded to the pipe outlet. A six-inch threaded piping nipple was used to mate the screen to the suction piping. The six-inch piping nipple was cut such that the threads were completely removed from one end. The cut end of the pipe was connected to the 90° elbow using a six-inch clamp-on pipe connector. Two ADCPs were installed on the riverbed directly upstream and downstream of the pilot wedgewire screens. These ADCPs collected current velocity data throughout the site-specific study.

A cam lock adapter was screwed on to the pipe nipple, which provided the means to connect the suction hose to the screen assembly. The pipe-elbow-nipple was assembled and connected to the hose on-shore, prior to lowering the screens into the river. As described in Addendum A, the suction hose was anchored to the riverbed with ten sets of anchors and tie wires, spaced equally along the portion of the hose that was resting on the riverbed.

Approximately two months after the installation of the pilot wedgewire screens, it was discovered that the 3.0 mm wedgewire screen was misaligned with the estimated sweeping flow direction by approximately 30°. The orientation was corrected and verified. Normal operation of the pilot wedgewire screens and scheduled samplings were reinstated following the correction.

Approximately three months after the installation of the pilot wedgewire screens, a design field change was implemented to mitigate corrosion due to dissimilar metals in the connection assembly between the 0.8 mm screen assembly and the suction hose. Following the observation of large debris in the 0.8 mm screen collection tank, divers discovered that the cam lock connecting the 0.8 mm screen assembly to the suction hose had corroded. The corroded cam lock caused damage to the suction hose on the connection side. The replacement of the connection assembly with a stainless steel variant and the replacement of the damaged section of hose with a suction hose of the same diameter but different specification was completed. In addition, a sacrificial zinc block was placed on both wedgewire screen connection assemblies to mitigate further corrosion. Following the field change, corrosion occurred on the zinc blocks rather than the connection assembly. No detrimental corrosion was observed following the installation of the sacrificial zinc blocks. Normal operation of the pilot wedgewire screens and scheduled sampling were restarted after the completion of the repairs.

2.2 SAMPLING PUMP AND FLOW METERS

Two Barmesa Model SH6-U Self-Priming Centrifugal Pumps were used for continuous withdrawal of water through the pilot wedgewire screens. The pumps were mounted on separate pump pads and placed in Screen House #1. The suction hoses coming in from the river were secured along the route from the intake tunnel to the pumps. The hoses were connected to six inch PVC pipe as shown in GSPL-00001-M-002, Sh. 1 Attachment 4. A vacuum gauge and flow meters were installed on the pipe, with one flow meter downstream of the vacuum gauge and another upstream of the sampling tank. PVC piping was field-routed to final placement of the pump, using PVC elbows as needed.

To protect the pump internals from exposure to saltwater, the cast iron components prone to long term exposure of saltwater from both pumps were removed and protected with a corrosion resistant coating. The components coated are highlighted in the exploded view from selected pages of the pump manual in Attachment 3. The recommended coating used was 3M Skotchkote 134, which was applied via a powder coating process.

To avoid corrosion of the externally shielded bearings, new sealed bearings were installed. Bearings of the same dimension as the Original Equipment Manufacturer (OEM) bearings were procured. The OEM bearings were replaced by the procured sealed bearings during the initial teardown inspection of the pumps which occurred prior to installation.

A Variable Frequency Drive (VFD) was used to control each pump to achieve and maintain the required flow rate and to trip the pump in the event of low suction pressure. The VFD operated the pump motor at an appropriate revolutions speed, in revolutions per minute (rpm), so that each pump delivered the flow specified in Table 2 (see Section 3.3). The VFD was mounted near the motor and connected to the motor as recommended by the manufacturer.

Each pump was mounted to a pre-cast concrete pad as shown on GSPL-00001-M-002, Sh. 2 Attachment 4 using anchor bolts. Two 13 in. long pieces of 3-1/2” x 3-1/2” x ¼” square tube steel were mounted to the concrete pad as indicated on the drawing using anchor bolts. The motor was bolted to the tube steel as indicated on GSPL-00001-M-002, Sh. 2. All bolt holes required for mounting the pump and motor were drilled field-to-fit.

To monitor flow rates through the pumps and into the collection tanks, magnetic flowmeters (magmeters) were installed upstream of each pump and upstream of each collection tank. The magmeters were manually calibrated because there was a lack of space in the screenhouse to provide sufficient straight pipe lengths for automatic calibration.

During the events when either screen became clogged (as detailed in Addendum C), a procedure to clear the screen for further testing was completed by site operating personnel (see Section 2.5). For this purpose, a cross-tie between the two pumps was installed in order to backflush a clogged screen. This took the form of an H-bridge of normally closed valves, bridging the intake and discharge of the two pumps. This allowed the use of one pump to clear the clogged screen of the other.

To prevent freezing in the piping in an abnormal event that the pump was not operational (i.e. trips on a low-pressure signal) during the winter, the pump and the piping configuration allowed water in the piping to be drained under gravity from the discharge and suction sides of the pump. A drain installed in the collection tank piping was used to empty the piping when the tank was drained per description in Section 2.3.

The operation and maintenance of the pumps was conducted by site personnel in accordance with past operation experience of similar pumps.

2.3 COLLECTION TANK PIPING

The sampling tanks were six feet (ft.), eleven inches tall, and the piping was routed to the base of the tank and up the side of the tanks until the proper height was achieved, and flow was then discharged into the tanks from above. The piping was installed as shown in Section B-B on GSPL-00001-M-002, Sh. 2 (Attachment 4). The piping was restrained in the horizontal direction with a four-inch plastic routing clamp that attached the piping to the edge of the collection tanks. A magmeter was installed more than five diameter lengths upstream of the elbow at the base of each tank and was used to ensure sufficient flow to the tank during the sample collection. A bypass line with valve was installed upstream of the magmeter. This bypass was routed to discharge into the active intake bay. A valve to isolate the tank was installed between the bypass line and the magmeter. A drain plug was installed at a low point of the piping between the bypass and the collection tank. All piping was field-routed, and pipe supports were added as necessary.

A procedure to fill and drain the tank was prepared. This procedure required the bypass valve to be normally open, with the tank isolated from the pump. When the tank needed to be filled for a sample collection, the tank isolation valve was opened in throttle position to achieve the desired flow rate into the tank. If the desired flow rate could not be achieved with the tank isolation valve fully opened, the bypass line valve was throttled to increase flow to the tank. Once the sample collection was complete, the bypass valve was returned to the fully open position and the tank was isolated from flow. The normally closed ball valve downstream of the tank was opened to allow the water in the tank to drain into the intake bay. After the water was drained, both the drain and the valve downstream of the tank were closed.

2.4 VACUUM GAUGE SWITCH

Excessive pressure loss across the pilot wedgewire screens had the potential to cause damage to the pumps and/or screens. The Net Positive Suction Head (NPSH) limits of the pumps would have been exceeded if there was not sufficient suction pressure. Excessive pressure loss across the screens would have caused the screens to collapse if the differential pressure across the screens was too great. To monitor this, vacuum gauges were installed upstream of the inlets of the pumps and the associated magmeters. The vacuum gauge switches displayed the negative gauge pressure (pressure below the atmospheric at the pump) in the line. When a gauge measured vacuum in excess of a set safety threshold, the gauge closed an internal single pole double throw (SPDT) switch, to completely deactivate the circuit of the associated pump VFD. The internal switch remained in the closed position until a hard reset of the gauge by an operator was performed. As per the paragraph below, the initial setpoints for tripping the pumps were 9.38 pounds-force per square inch gauge (psig) vacuum (19.10 inches of mercury [inHg]) and 7.98 psig vacuum (16.25 inHg) for the gauges associated with the 3.0 mm screen and 0.8 mm screen, respectively. The re-trip point for both gauges was set at the highest reading of vacuum available, which was 14.70 psig vacuum (29.93 inHg). To avoid a false low suction pressure reading due to startup transients, a normally open inline switch was installed on the leads connecting each gauge to the respective VFDs. Once the gauge readout confirmed steady state, the inline switch actuated to the closed configuration. Under normal operations, the vacuum value gauge readout was as an analog 4-20 mA signal sent to a data logger. The frequency of the data collection was set according to the desired resolution. On a regular basis, the data from the logger was downloaded for processing.

According to the pump curve for the Barmesa SH6-U pump with an 11 in. impeller, the Net Positive Suction Head required (NPSHr) at flow rates of 361 gallons per minute (gpm) for 3.0 mm screens and 201 gpm for 0.8 mm screens at the highest motor speed is approximately 8.5 feet of water column (ft-H_2O) and 7.5 ft-H_2O, respectively, as seen in Figure 1. This corresponds to the pump suction pressure readings of approximately 3.7 psia and 3.2 psia, respectively. These pressures correspond to readings of approximately 11.0 psig vacuum and 11.5 psig vacuum, respectively.

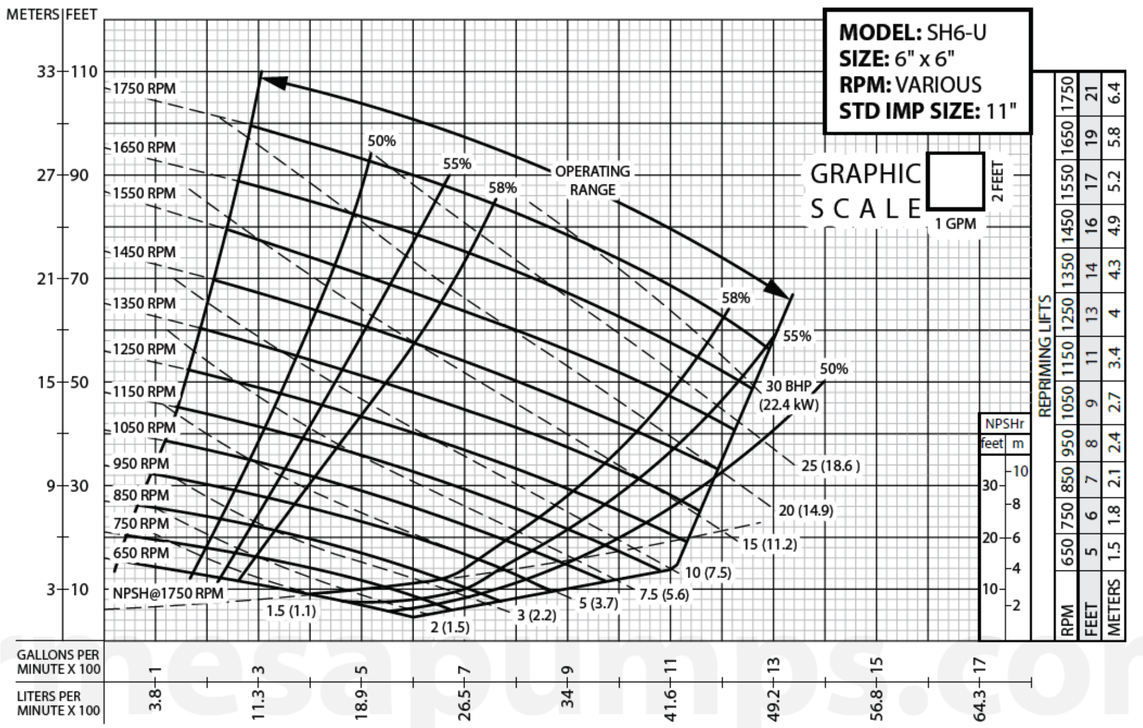

Figure 1: Barmesa SH6-U pump curve for an 11-inch impeller

The hydrostatic collapse pressure for 3.0 mm and 0.8 mm screens are both 4.34 psig, per vendor specification sheet (Ref. 6.12 and Ref. 6.13). Calculating the Net Positive Suction Head available (NPSHa) at the point of screen collapse (i.e. atmospheric pressure minus elevation difference minus vapor pressure minus head loss from piping minus hydrostatic collapse pressure) reveals the pressure directly upstream of the pump when the screen would collapse.

At Mean Lower-Low Water conditions, comparing the Net Positive Suction Head required (NPSHr) versus NPSHa at screen collapse results in cavitation occurring before the screen collapsing. But since NPSHr was based on vendor testing and is a fixed value, the suction pressure at which the screen collapses is a function of NPSHa which varies with river level. Table 1 details the minimum allowable suction pressure to avoid pump cavitation or screen collapse, whichever would occur first at the corresponding tide level. Cavitation would have occurred at 10.15 psig and 10.59 psig (vacuum) for the 3.0 mm and 0.8 mm screens, respectively. Screen collapse would occur at lower psig vacuum values during high tide levels as in Table 1. Therefore, the bounding scenario for tripping the pump was Mean Higher-High Water for both screens. A safety factor of two ft-H_2O was included in the trip set point by adding two ft-H_2O to the maximum value between the NPSHr and the suction pressure at screen collapse.

Table 1: Allowable maximum vacuum reading (psi) [1]

Tide level		Suction Pressure, psig	
Description	**Elevation [2], ft**	**3.0 mm**	**0.8 mm**
Mean Higher-High Water	9.39	9.38	7.98
Mean High Water	8.97	9.56	8.17
Mean Tide Level	4.65	10.15	10.04
Mean Sea Level	4.69	10.15	10.02
Mean Diurnal Tide Level	4.7	10.15	10.01
Mean Low Water	0.34	10.15	10.59
Mean Lower-Low Water	0	10.15	10.59
North American Vertical Datum of 1988	5	10.15	9.88
Station Datum	-2.71	10.15	10.59

The values in Table 1 were used as a guide for detecting problematic conditions related to the wedgewire screen.

2.5 BACKFLUSH PROCEDURE

Upon blockage of either screen, a backflush procedure was initiated to clear the screen so that testing could continue (as described in Addendum C). This section documents the backflushing procedure. The backflushing event begins with the automatic shutdown of the pump associated with the clogged screen, as per Section 2.4. Once the pump was fully shutdown, the normally open valve between it and its associated collection tank assembly was closed. In sequence, 1) the normally closed H-bridge valve upstream of the shutdown pump was opened, 2) the normally closed H-bridge valve downstream of the operational pump was opened, and 3) the normally open valve downstream of the operating pump was closed to divert all flow through the cross-tie. This

[1] Note that the values in this table are in "psi" below atmospheric pressure.
[2] Elevation is relative to MLLW water level

configuration redirected the operating pumps flow to backflush the clogged screen. Once the procedure was completed, the valves were reconfigured in the reverse order. Then, the vacuum gauge was hard reset to restart the shutdown pump. Flow and pressures were monitored on restart to verify that all valves were fully closed and opened in the correct configuration. An event report capturing one backflushing event is provided in Addendum C.

2.6 CONTROL SAMPLING TANK

To supply a control sample to compare to samples collected through the screens, a portion of the intake water from the existing Unit 5 Screen 5A pump was diverted to a collection tank of similar construction to the test sampling tanks. The site's configuration had a flanged valve tapped off the Screen 5A circulation water pump connected to a capped section of PVC piping. With the valve fully closed, the PVC end cap was cut off, and new PVC piping was installed to the controlled sampling tank. The pipe was field routed out of Screen House #2 and into the sample collection tank. When required, the normally closed tap off isolation valve was opened to collect control samples. After sufficient sampling of the control was acquired, the isolation valve was fully closed and the water in the collection tank emptied. Once the collection tank was emptied, the drain plug on the piping leading to the tank was opened momentarily to avoid standing water in the piping. The system was installed as shown in GSPL-00001-M-004, Sh. 2 Attachment 4.

3.0 SUPPORTING ANALYSIS

This section provides the details of the engineering analysis efforts that were conducted to support the design and implementation of the in-river testing setup. The analyses were conducted to evaluate the impact of the Hydraulic Zone of Influence (HZOI) of the intake structure and the drag force exerted by the sweeping river flow are detailed below. The analysis performed to support the sizing of the pump is also detailed below.

3.1 HYDRAULIC ZONE OF INFLUENCE ANALYSIS

To ensure that the screens were installed sufficiently far from the intake structure to avoid interference effects, an evaluation was performed to assess the impact of the HZOI of the intake structure. This was used to determine the appropriate distance from the intake and ensure that interference effects were negligible.

The ADCP data gathered prior to installation of the pilot wedgewire screens concluded that the average river velocity is approximately 2.6 ft/sec. With this data, it was determined that a sweeping flow deflection of less than two degrees at a distance of 100 ft. into the river would occur due to the suction generated by the intake structure. This small deflection was determined to be sufficiently negligible. The analysis validates an effective minimum distance of 100 ft. The location at which the pilot wedgewire screens were placed was in excess of the preliminary distance of 100 ft. This concluded that the hydraulic influence of the intake did not negatively impact test sampling results.

3.2 SUCTION HOSE DRAG FORCE

To ensure that an adequate anchoring force was provided to prevent the intake hose position from being impacted by the sweeping river flow, a force analysis was performed. The exerted forces that the intake hoses were experiencing was the difference between the drag force from the sweeping river flow, and the counteracting hose friction between the hose and the riverbed. Calculations for each are detailed below.

The drag force acting on the intake hoses was due to the sweeping river flow. It was calculated using the following equation (Ref. 6.3, p. 17-41):

$$F_D = \frac{C_D * \rho * v^2 * A}{2g}$$

Where:

F_D = the drag force exerted on the hose (lb_f)

C_D = the drag coefficient (unitless)

ρ = the density of water (lb_m/ft^3)

v = the velocity of the sweeping river flow (ft/sec)

A = the projected area of the hose (ft^2)

g = gravitational constant (32.174 lb_m-ft/lb_f-sec^2)

The drag coefficient of flow over a cylinder resting on the ground is approximately 0.8 (Ref. 6.6 and 6.7). The density of the water at normal conditions was estimated to be 62.4 lb_m/ft^3. The projected area of the intake hose perpendicular to the current direction was represented as a rectangle, equal to the hose outer diameter multiplied by the hose length. The projected area was calculated to be 90 ft^2, as shown below.

$$A = D * L = \left(6.81\, in\, * \frac{1\, ft}{12\, in}\right) * 159\, ft = 90\, ft^2$$

The maximum sweeping river velocity in the vicinity of the screens was 7.1 ft/sec (Ref. 6.10). This velocity of the river was assumed to not be bounding since the river could experience a higher sweeping velocity.

The drag force experienced by the intake hose was then calculated to be 3,529 lb_f, as shown below.

$$F_D = \frac{C_D * \rho * v^2 * A}{2g} = \frac{0.8 * 62.4\, \frac{lb}{ft^3} * \left(7.1 \frac{ft}{sec}\right)^2 * 90.3\, ft^2}{2} * \frac{1\, lbf}{32.2\, \frac{ft * lb}{sec^2}} = 3{,}529\, lbf$$

The counteracting friction for the intake hoses was equal to the net weight of the hose multiplied by the static friction coefficient of wet sand and PVC, estimated to be 0.55. The net weight was calculated by taking the difference between the weight of the hoses and the buoyancy.

The net weight of the intake hoses was calculated by multiplying the total length of both hoses, 318 ft., by its linear weight of 4.88 lb_f/ft per the intake hose manufacture. Because the water inside the hose is of the same density as the ambient water, no additional net weight of the water is accounted for. The weight of the intake hose was equated to 1,551.84 lb_f.

The buoyancy was calculated by multiplying the volume of water displaced by the density of the water. The volume of displaced water was calculated to be 13.60 ft^3, as shown below.

$$Water\ Displaced = \frac{\pi * (Do^2 - Di^2)}{4} * L * .75 = \frac{3.14 * (.568^2 ft - .50^2 ft)}{4} * 318\ ft * .75$$
$$= 13.60\ ft^3$$

Where:

Do = the outer diameter (feet)

Di = the inner diameter (feet)

L = the length of the hose (feet)

A factor of 0.75 was applied to account for the half thickness along half the length of hose due to ridges on the outside of the hose.

The buoyancy was then calculated by multiplying the volume of displaced water of 13.60 ft^3 by the density of the water of 62.4 lb_m/ft^3 equating to 848.64 lb_f. The difference between the hose weight of 1,551.84 lb_f and its buoyancy of 848.64 lb_f equating the net weight to 703.2 lb_f.

The hose friction force was then calculated by multiplying the net weight of 703.2 lb_f by the static friction coefficient of 0.55, equating to 386.76 lb_f.

The total force that was required to secure the intake hoses was then calculated by taking the difference between the drag force of 3,529 lb_f and the friction force of 386.76 lb_f equating to 3,142.24 lb_f, therefore an anchoring force was required.

For anchors to keep the hoses stationary against the sweeping river flow, the minimum additional force of 3,142.24 lb_f was required.

Please refer to Addendum A for the intake hose anchoring equipment detail.

3.3 PUMP SIZING

The sampling pumps for the pilot wedgewire screens were sized to be able to draw sufficient flow through the screens given the hydraulic resistances present in the system. To size the pumps for the study, the pump sizing evaluation performed in the Site-Specific Study Scope (Ref. 6.5) was revised to incorporate the setup from the detailed design.

The pump design flow rates were 361 gpm and 201 gpm for the 3.0 mm and 0.8 mm screens, respectively. These flow rates were determined using the design through-slot velocity of 0.4 ft/sec. For simplicity, the pump sizing conservatively assumed that all flow was delivered to the tank. Since the bypass flow discharged at a lower elevation than the tank discharge and did not contain a long run of piping, this simplification was conservative for the pump sizing. The pump sizing evaluation also considered the NPSH to ensure that pump cavitation would not be an issue.

Hose Hydraulic Losses

The hydraulic losses in the hose were estimated using the methodology in the Fire Protection Handbook (Ref. 6.1).

Using the Fire Protection Handbook methodology, the expected pressure loss through the hose was calculated as the following.

$$FL = cq^2L$$

Where:

FL = friction loss (psi)

c = friction loss coefficient

q = flow rate (gpm x 100)

L = length of hose (feet x 100)

The hydraulic losses were estimated for both the suction and discharge hoses. The results are shown below in Table 2. Hose lengths are based on drawings, procured test materials and the placement of the screens.

Table 2: Hose hydraulic losses and inputs

	3.0 mm		0.8 mm	
	Suction	**Discharge**	**Suction**	**Discharge**
Flow Rate (gpm)	361	361	201	201
Hose Diameter (inches)	6	4	6	4
Friction Loss Coefficient (Ref. 6.1)	0.05	0.2	0.05	0.2
Hose Length (feet)	230	25	230	25
Friction Loss (feet)	3.46	1.51	1.07	0.47

Piping and Fitting Losses

There was additional head loss on the suction and discharge sides of the pump, due to the short runs of piping available inside the screenhouse. The suction and discharge piping used was six inches and four inches in diameter. The head loss through the piping sections was evaluated using the methodology shown below (Ref. 6.2, p. 385).

$$h_L = \frac{v^2}{2g}\left(\frac{fL}{D} + K\right)$$

Where:

h_L = Head loss (ft-H_2O)

v = Velocity (ft/sec)

g = Acceleration due to gravity (32.2 ft/s^2)

f = Friction factor

L = Pipe length (feet)

D = Pipe inner diameter (feet)

K = Minor loss coefficient

The inputs and calculated parameters for the piping head loss are shown below in Table 3.

Table 3: Piping head loss inputs and parameters

Parameter	3.0 mm		0.8 mm		Unit	Notes
	Suction	Discharge	Suction	Discharge		
Pipe Inner Diameter	6.065	4.026	6.065	4.026	inch	Sch. 40 pipe size.
Flow Rate	361	361	201	201	gpm	System design flow rate
Assumed Temperature	50	50	50	50	°F	Portsmouth, NH
Water Kinematic Viscosity	1.41E-05	1.41E-05	1.41E-05	1.41E-05	ft^2/s	Ref. 6.3, p. A-16
Length of Pipe	10	30	10	30	feet	
Pipe Roughness (ε)	0.000005	0.000005	0.000005	0.000005	feet	For PVC. Ref. 6.3, p. A-48
Velocity	4.00	9.09	2.23	5.06	ft/s	
Reynolds Number (Ref. 6.2)	143,048	215,495	79,687	120,045	--	
Flow Regime	Turbulent	Turbulent	Turbulent	Turbulent		
Relative Roughness (ε/d)	9.89E-06	1.49E-05	9.89E-06	1.49E-05	--	
Turbulent Friction Factor	0.017	0.015	0.019	0.017	--	Moody Chart analytical approximation, see below

The turbulent friction factor was estimated using the Zigrang/Sylvester explicit approximation of the Moody Chart, shown in the equation below (Ref. 6.4).

$$f = \left\{-2\log\left[\frac{\varepsilon}{3.7} - \frac{5.02}{\mathrm{Re}}\log\left(\varepsilon - \frac{5.02}{\mathrm{Re}}\log\left(\frac{\varepsilon}{3.7} + \frac{13}{\mathrm{Re}}\right)\right)\right]\right\}^{-2}$$

Based on the design drawings and assumed piping configuration, the following fittings and minor losses were considered for both runs of four inch diameter piping.

Table 4: Piping minor loss coefficients

Fitting	Qty.	K_{each}	K_{total}	Notes
Reducer	1	0.3	0.3	Assume sudden contraction. Ref. 6.2, p. 390.
Ball Valve	1	1.6	1.6	Assume fully open gate valve. Ref. 6.2, p. 387.
90° elbow	2	0.6	1.2	Ref.4.2, p. 387. Long radius.
45° elbow	2	0.42	0.84	Ref.4.2, p. 387. Short radius for conservatism.
Tee	1	1.8	1.8	Ref. 6.2, p. 387.
Exit	1	1	1	Ref. 6.2, p. 390.
Misc. Allowance	NA	NA	5	To cover unaccounted for flow disturbances (e.g., hose fittings)
TOTAL	11.74			

For each of the six-inch piping runs, a 90° elbow was attached to the bottom of the wedgewire screen. A K value of 0.9 was utilized for the elbows (Ref 4.2, p. 387). In addition, a miscellaneous allowance of K=2 was added to account for the various line adaptors and the flow and pressure meters. This conservative number was based on engineering judgement. Therefore, the total K value for each six-inch piping run was 2.9. Because the suction hose had a minimum bend radius of 24 in. or greater [3], bends in the hose were not considered flow disturbances, and only the distance from the pump suction was considered.

The total head loss through the suction and discharge piping on the 3.0 mm and 0.8 mm lines are displayed in Table 5.

[3] Per Figure 6.20 of "Fluid Mechanics – 5th Edition", Frank M. White, a R/d of 4 or greater is no longer considered a piping elbow. (R = bend radius, d=inner diameter).

Table 5: Total head loss (ft-H_2O) through pipe

	3.0 mm	0.8 mm
Suction	0.58	0.18
Discharge	16.83	5.29
Total	17.41	5.47

Wedgewire Screen Head Loss

From the wedgewire screen vendor specification sheets the listed head loss across the 3.0 mm and 0.8 mm screens were 0.0035 pounds-force per square inch (psi) and 0.0041 psi, respectively. These values were based on the screens being completely clean and were only an "estimated" head loss value, these values were conservatively quadrupled for the purposes of pump sizing. The head loss through the entire screen assembly was 0.1642 psi and 0.0669 psi for the 3.0 mm and 0.8 mm screen, respectively. Converting to feet of water and replacing the clean screen head loss with the modified head loss values, the head loss through the screen assemblies was 0.40 ft-H_2O and 0.18 ft-H_2O for the 3.0 mm and 0.8 mm screens, respectively.

Elevation Head

Based on Reference 4.8, the Mean Lower-Low Water (MLLW) elevation was 0 ft. The floor elevation in Screen House #1 platform was assumed to be equivalent to the elevation of the loading dock, based on site walkdown photos, which was 11.62 ft. relative to the North American Vertical Datum of 1988 (NAVD88), or 16.6 ft. relative to MLLW, per Ref 4.9. Per design drawings for the pump skid and the sampling pumps, the pump centerlines were elevated to 1.2 ft. above the screen house floor, resulting in a pump centerline elevation of 17.8 ft. Sampling tanks were equivalent to those used in Merrimack testing and had a height equivalent to those from Merrimack testing of six feet, eleven inches. Because the piping emptied into the tank directly above the top of the tank, a height of 8 ft. was used. Therefore, the elevation head was 25.2 ft-H_2O.

Total Dynamic Head

The total dynamic head requirement for the pumps was the sum of all the hydraulic head losses determined in the pump sizing calculations. As shown below.

Table 6: Total dynamic head calculation for the sampling pump (ft-H_2O)

	3.0 mm	0.8 mm
Suction Hose Loss	3.64	1.07
Discharge Hose Loss	1.51	0.47
Piping and Fitting Loss	17.41	5.47
Wedgewire Screen Loss	0.40	0.18
Elevation Head	25.84	25.84
TOTAL DYNAMIC HEAD	**48.80**	**33.03**

The values for the total dynamic head were based on a pre-installation evaluation. These values are conservative due to the actual installation resulting in a lower total dynamic head. The total dynamic head was significantly lower than initially calculated, due to the final construction having shorter runs of piping and fewer elbow bends inside the screenhouse than the original design.

Based on the evaluation above, the Barmesa model SHU-6 pump from Merrimack testing was sufficient for use on the 3.0 mm line for Schiller's testing, at a required flow rate of 361 gpm at 49 ft-H_2O. From the pump curves, the pump operated at 1,250 rpm therefore, a VFD was required for the 1,800 rpm motor. The pump procured for the 0.8 mm line had a lower performance requirement of 201 gpm at 33 ft-H_2O and the pump operated at 1,000 rpm. Therefore, the procured pump was identical to the pump from Merrimack testing so that either pump could be used (via the cross-tie) and still meet the total dynamic head requirements.

Net Positive Suction Head Available

The centrifugal pumps required sufficient suction head to ensure that damage to the pump would not occur. It was noted that if the pump suction pressure was too low (i.e., vacuum), water vapor bubbles would damage the pump. For this reason, the Net Positive Suction Head available (NPSHa) was calculated and compared to the NPSH required (NPSHr) by the pump.

Net positive suction head was defined as the following (Ref. 6.3, p.18)

$NPSHa = h_{atm} + h_z - h_{ft} - h_{vap}$

h_{atm} = Atmospheric pressure, converted to ft-H_2O

h_z = Elevation difference between pump suction and water surface (feet) (negative if pump is located above water surface)

h_f = Friction losses on suction side of pump (ft-H_2O)

h_{vap} = Vapor pressure of water converted to ft-H_2O

Table 7: Net positive suction head values and inputs

Parameter		3.0 mm	0.8 mm	Notes
Atmospheric Pressure (h_{atm}) (ft-H_2O)		33.9	33.9	Ref. 6.3, p.18-15
Difference between pump suction and water surface (h_z) (ft-H_2O)		17.84	17.84	
Vapor pressure (h_{vap}) (ft-H_2O)		0.42	0.42	0.18 psia at 50°F per Ref. 6.3, p. A-62.
Friction Losses (h_f) (ft-H_2O)	Suction Hose	3.64	1.07	See Table 2
	Wedgewire Screen	0.40	0.18	See Table 5
	6-inch piping	0.58	0.18	See text below Table 4
NPSHa (ft-H_2O)		11.20	14.21	h_{atm}-h_z-h_{vap}-h_f

As shown in Table 7, the 3.0 mm suction line had the limiting NPSHa. Based on the pump curve for the Barmesa SH6-U pump that was procured, the NPSHr with an 11 in. impeller and flow rate of 361 gpm was 8.5 ft-H_2O at the highest pump speed of 1,750 rpm. The limiting NPSH margin (NPSHm) occurs on the 3.0 mm screen line and was at (111.20 – 8.5050) 2.070 ft-H_2O. Per the pump curve, the 3.0 mm screen line pump operated at 1,250 rpm. The tide level was monitored during testing period. There was sufficient NPSHm during the testing period.

Because of the relatively small magnitude of the limiting NPSHm, all parameters affecting the pump NPSHa, such as pump elevation, were closely monitored during installation.

3.4 WEDGEWIRE SCREEN SUPPORTS

An analysis of the wedgewire screen supports for structural stability is included in Attachment 5. Note that the analysis was done for a conservative six-inch thick concrete pad. The 12-in. pad used and depicted in GSPL-00001-SK-001, and GSPL-00001-SK-02, Attachment 4 had a higher factor of safety than the one analyzed. The screen support design accounted for the 12-in. pad used when assessing screen centerline height. Also note that the Hilti Anchor rods used were 304 stainless steel rather than A307 carbon steel, added for corrosion resistance. 304 stainless steel was a vendor approved material for the anchoring system.

4.0 POST-TESTING CONDITIONS

Following the conclusion of the testing period, the pilot wedgewire screens were found to be in an ineffective condition due to a significant amount of damage and fouling. Detailed condition findings from during and following the testing period are provided in Addendums C through E. The variable tidal patterns, ambient water quality, submerged debris and high velocity sweeping river flow resulted in both pilot wedgewire screens developing relatively large openings. Additionally, the conditions in the Piscataqua River led to the clogging of a large surface area by siltation and biogrowth. A summary of the conditions is provided in Table 8. An image of each pilot wedgewire screen after retrieval is provided in Figure 2. Note that a significant amount of fouling material was incidentally removed during retrieval of the screens. Regions of dark discoloration on the screens indicate locations of accumulated fouling deposits present during the pilot study. Underwater imagery showing the amount of fouling present on the screens during the pilot tests are provided in Addendums C through E.

Table 8: Wedgewire Screen Conditions Summary

Screen	Final Proportion of Screening Area Damaged	Estimated Flow Through Final Damaged Area	Width of Largest Damage Opening	Peak Proportion of Screening Area Clogged
3.0 mm	15.5%	23%	2.5 inch	21%
0.8 mm	19.25%	44.5%	3.5 inch	36%

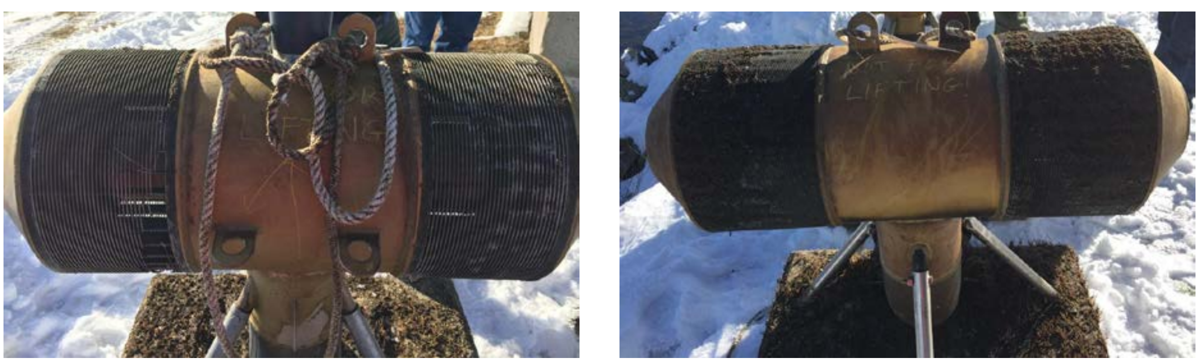

Figure 2: Post-Testing Wedgewire Screen Conditions (Left: 3.0 mm Pilot Wedgewire Screen, Right: 0.8 mm Pilot Wedgewire Screen, Note: Images Do Not Reflect In-Water Fouling Conditions Due to Material Removed During Retrieval)

5.0 CONCLUSIONS

The Wedgewire Screen Site-Specific Study demonstrated the difficulty of installing and operating wedgewire screens at Schiller Station. The excessive amount of damage and fouling observed on both pilot wedgewire screens indicates that a full-scale installation of wedgewire screens in the vicinity of Schiller Station would likely have a brief lifespan, unreliable availability and reduced effectiveness that further degrades over time. Additionally, the variable and location-dependent ambient currents create susbstantial uncertainty regarding entrainment reduction performance. The characteristics observed during the in-situ testing period are considered representative of what should be expected from a full-scale installation of this wedgewire screen technology.

The collection of damage and fouling on the pilot wedgewire screens was first identified after seven months of continuous operation (see Addendum C), prior to which the pilot wedgewire screens were in acceptable conditions based on diver visual inspections. The remainder of the test period was characterized by a rapid increase of the proportion of damage and persistent fouling on both pilot wedgewire screens. A full-scale wedgewire screen assembly with a corresponding amount of damage and fouling would require extensive repairs or replacement for continued operation. A technology lifespan as low as one year would result in frequent downtime and costly maintenance. The removal from service of full-scale wedgewire screens due to excessive damage and fouling would require the use of an emergency bypass in conjunction with other screening technologies until the wedgewire screen could be restored to acceptable conditions. Based on the results of the site-specific study, this could occur on an annual, or likely more frequent, basis. Further, the removal of ineffective screens from service would be dependent on observation of damage and fouling. Monitoring of damage and fouling would be difficult to observe through intake bay drawdown due to the low head loss across wedgewire screens. Due to the high turbidity of the ambient water and location where full-scale wedgewire screens would be installed, visual observation would require periodic dive inspection. Therefore, screens in service at reduced effectiveness could continue operating in unacceptable conditions for extended periods until observed by planned or emergent dive inspection.

The exclusionary performance of wedgewire screens is dependent on several factors, including current velocity, current direction, and tidal stage. Wedgewire screens are designed to operate in constant sweeping flows in order to develop a hydraulic bypass effect and provide sufficient screening effectiveness. As demonstrated during the site-specific study, excessively high ambient current velocities may cause entrainment of fish eggs or larvae of larger size than the screen opening due to extrusion effects. The current velocity and current direction during the testing period were observed to be inconsistent and variable based on location, time, tidal stage, and season. These factors will likely produce poor performance during at least some high entrainment periods. Performance of a full-scale wedgewire screen system would likewise be uncertain due to these varying ambient conditions caused by unpredictable tidal effects.

Due to the relatively large footprint of a full-scale wedgewire screen installation, the impact of the tidal conditions would be compounded. The likelihood that a screen or a portion of a screen would be misaligned to the current would increase with the expanded footprint. Misalignment could result in collision or impingement of submerged debris or aquatic organisms, detrimental extrusion effects, and reduced hydraulic bypass, among other unfavorable impacts.

The results of the Wedgewire Screen Site-Specific Study indicate that the availability and effectiveness of a full-scale installation of wedgewire screens would be uncertain and unreliable. The installation and operation of full-scale wedgewire screens would encounter the issues observed during the site-specific study and may result in further issues unique to full-scale installations. For these reasons, the installation of wedgewire screens at Schiller Station would be a difficult and imprudent measure which would not provide reliable, year-round operation.

6.0 REFERENCES

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6.5 Wedgewire Screen Site-Specific Study Scope Description. Enercon Services, Inc. July 2018.

6.6 Hongwei, An; Cheng, Liang; Zhao, Ming. Numerical Simulation of a Partially Buried Pipeline in a Permeable Seabed Subject to Combined Oscillatory Flow and Steady Current. 2011.

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6.9 Mooring and Berthing Operational Procedures, Public Service of New Hampshire Schiller Station, Portsmouth, New Hampshire, January 2015

6.10 Survey Report on Water Velocity and Bathymetry near Schiller Station, Normandeau Associates, Inc., July 2018.

6.11 PE26 Specifications, American Earth Anchors.

6.12 Aqseptance Group, Inc. Quotation Number 20035296 Revision A. Johnson T-12HC 3.0 mm Intake Screen. February 2017.

6.13 Aqseptance Group, Inc. Quotation 20056124 Revision A. Johnson T-12HC 0.8 mm Intake Screen. August 2018.

6.14 Enercon Services, Inc. Response to Environmental Protection Agency's Statement of Substantial New Questions For Public Comment. Prepared for Public Service Company of New Hampshire D/B/A Eversource Energy. December 2017.

COMPONENT SPECIFICATION #001

Cylindrical Wedgewire Screen

Two Johnson Screens T-12 cylindrical wedgewire screens were used for the confirmatory testing. As discussed in the confirmatory testing scoping document, a 12-in. full cylindrical screen provides a reasonable representation of the expected flow field over a 96-in. half screen. Each screen was supported by a tripod stand mounted on a concrete foundation such that the screen centerline was approximately 39.75 in. above the riverbed.

Design and Construction:	12–in. diameter cylindrical wedgewire screen with slot sizes of 3.0 mm and 0.8 mm and average through-slot velocity of 0.4 ft/sec. Tripod legs to elevate screen centerline to 39.75 inches above floor.
Material:	Z-Alloy screening material, Z-Alloy and stainless steel tripod legs, non-metallic or insulated connections between dissimilar metals.
Performance:	Shall be designed to pass flow at an average through-slot velocity of at least 0.4 ft/sec.
Packaging, Shipping, and Storage:	Wedgewire screen shall be inspected for damage upon receipt. The dimensions shall be verified against the fabrication drawings.
Electrical Requirements:	N/A
Documentation:	Shop fabrication drawings of tripod support, as well as vendor operation and maintenance manual.
Codes, Standards, and/or Regulations:	N/A
Installation:	Shall be installed in at least 20 ft-H_2O, with the centerline of the screen approximately 39.75 in. above the bottom.
Testing and Inspections:	Flow loop test shall be conducted to verify that the screen can pass the required flow.

COMPONENT SPECIFICATION #002

Piping and Hose

The following pipes and hoses were used in the testing design.

- 4-inch and 6-inch suction hose
- 3-inch and 4-inch discharge hose
- 4-inch and 6-inch PVC piping

Design and Construction:	• 6-in. suction hose shall be rigid, suction hose with a bend radius of 24 in. or greater. Hoses shall be outfitted with cam lock fittings. • 4-in. suction hose shall be rigid, suction hose with a bend radius of approximately 6-12 in. • 3-in. and 4-in. discharge hoses shall be lay-flat hose with cam lock fittings. • PVC piping shall be Schedule 40.
Material:	• Suction hose shall be PVC or rubber with a smooth interior surface. • Discharge hose shall be rubber or puncture resistant fabric.
Performance:	• Suction hose shall be rated for full vacuum. • 3-in. and 4-in. discharge hoses shall have a pressure rating of 70 psig or greater.
Packaging, Shipping, and Storage:	Materials shall be inspected upon receipt for damage.
Electrical Requirements:	N/A
Documentation:	N/A
Codes, Standards, and/or Regulations:	PVC Pipe – ASTM D1785
Installation:	Piping and hose shall be installed in accordance with design and layout drawings.
Testing and Inspections:	A flow loop test shall be conducted on all piping and hose prior to testing to ensure their integrity and leak-tightness.

COMPONENT SPECIFICATION #003

Vacuum Pressure Gauge

A vacuum gauge was procured to allow the head loss on the suction side of the pump to be monitored. This allowed for an indication of screen blockage or other issues that may cause damage to the pump and/or screen. The vacuum gauge also acted as a trip switch for the associated pump upon a threshold clogging pressure as to avoid damage to the system with a controllable, semi-permanent pump shutdown.

Design and Construction:	Vacuum pressure gauge must have a 1/4-in. NPT male threaded connection, a digital read-out, and a pressure range from zero to one atmosphere (29.9 inHg).
Material:	Shall be constructed of materials suitable for extended outdoor exposure, such as polycarbonate or plastic. Connection material shall be corrosion resistant, such as stainless steel.
Performance:	Shall report pressure in either psi or inHg to at least one decimal (i.e., tenths place). Shall output in a recordable format. Shall send a trip signal at a programmable setpoint.
Packaging, Shipping, and Storage:	Materials shall be inspected upon receipt for damage.
Electrical Requirements:	An AC to DC power supply shall be provided which outputs 12 to 36 VDC and has a current capacity of at least 1 amp. Power supply shall ultimately originate from a 120 VAC source.
Documentation:	Vendor operation and maintenance manuals.
Codes, Standards, and/or Regulations:	NIST traceable calibration
Installation:	Vacuum pressure gauge shall be installed vertically on top of the 6-in. PVC pipe, prior to the sampling pump suction flange connection. A drill and 1/4-in. NPT tap shall be used to tap a small hole in the PVC pipe for mounting the gauge.
Testing and Inspections:	Test to ensure that the zero reading (atmospheric) is correct. If a vacuum pump is readily available, test to ensure that the vacuum readings are as expected and repeatable.

COMPONENT SPECIFICATION #004

Test Pump

An electric motor-driven pump was used to draw water through the screen and pump it to the sampling tank. The pump was a solids handling trash pump capable of passing solids of at least 3.0 mm in diameter. The pump was placed on a platform on the north side of the Unit 1 intake. The pump was self-priming and electrically powered. The pump was bolted to the pump skid and rest atop the angle irons.

Design and Construction:	Solids handling trash pump with open impeller, 6-in. flange connections.
Material:	Wetted materials shall be steel or cast iron, pump seals shall be silicon carbide
Performance:	251 gpm with a total dynamic head of 60 ft-H_2O or greater, suction lift of 15 ft. or greater, self-priming, can pass particle of 3.0 mm diameter or larger
Packaging, Shipping, and Storage:	Delivered on skid to site. Upon receipt inspect pump for visible flaws and perform validation testing.
Electrical Requirements:	Motor-driven, 480 V, three-phase power source through a variable frequency drive (VFD).
Documentation:	Vendor operation and maintenance manual.
Codes, Standards, and/or Regulations:	ASME B73.1
Installation:	Place skid on west side of platform with pump suction facing the river. Install piping in accordance with design drawings.
Testing and Inspections:	Test to ensure that at least 375 gpm can be pumped. Visual inspection should occur to ensure no damage to the pump during shipment. Pump should be operated and maintained in accordance with vendor instructions.

COMPONENT SPECIFICATION #005

Flow Meter

Magnetic flow meters were procured to allow the flow rate throughout the system to be monitored. One flow meter was installed on each pump suction to measure the flow rate passing through the pilot wedgewire screens, and one flow meter was installed on each sampling tank inlet line to ensure that the sampling flow rate is appropriate.

Design and Construction:	The flow meters shall have a digital read-out and the capacity to measure the flow rate through a PVC pipe. The meter shall be suitable for installation on a 6-in. line and a 4-in. line. Or, otherwise, procured separately two models for installation as such.
Material:	Shall be constructed of materials suitable for extended outdoor exposure, such as polypropylene, and the wetted material shall be corrosion resistant.
Performance:	Shall display flow in gpm with resolution to the ones value, with no more than 2% of reading linearity. Flow meter shall not create significant pressure drop.
Packaging, Shipping, and Storage:	Materials shall be inspected upon receipt for damage.
Electrical Requirements:	An AC to DC power supply shall be provided which outputs 5 to 24 VDC and has a current capacity of at least 0.2 amps. Power supply shall ultimately originate from a 120 VAC source.
Documentation:	Vendor operation and maintenance manuals.
Codes, Standards, and/or Regulations:	N/A
Installation:	Flow meter shall be installed sufficiently downstream and upstream of flow disturbances. Typically, 15-diameters upstream and 5-diameters of downstream clearance are required. Consult the vendor manual for the flow meter.
Testing and Inspections:	Test as part of the flow loop test to ensure that flow measurements are as expected and repeatable.

COMPONENT SPECIFICATION #006

Ball Bearings

Sealed ball bearings were procured to replace the shielded ball bearings inside the test pump to prolong the operating life of the pumps.

Design and Construction:	Sealed ball bearings measuring 50 mm ID, 110 mm OD and 27 mm 44.5 mm widths.
Material:	Outer and inner race shall be constructed of pressed steel. Seal shall be made of rubber to keep cooling water out of lubricated retainer.
Performance:	Dynamic loading up to 38 kN, low friction up to limiting speed of 4,000 rpm and inner race tolerance of below 15µm.
Packaging, Shipping, and Storage:	Materials shall be inspected upon receipt for damage.
Electrical Requirements:	N/A
Documentation:	N/A
Codes, Standards, and/or Regulations:	N/A
Installation:	Bearings shall replace the shaft bearings installed in the test pump. The single wide bearing is to be installed as the inboard bearing. The double wide bearing is to be installed as the outboard bearing.
Testing and Inspections:	Prior to installation, hand turn test pump impeller to inspect original bearing fit and friction. After installation, hand turn impeller to inspect and compare fit and friction. To be tested with test pump flow testing. Audible inspection for any rattling, squeaking, etc.

COMPONENT SPECIFICATION #007

Requirements for Pilot Wedgewire Screens Concrete Pad

A pre-cast concrete pad was procured to be installed and placed below the pilot wedgewire screens. This is to allow the pilot wedgewire screens to sit on the surface of the riverbed and not intrude into soil below.

Design and Construction:	(Two) 3’-0” x 3’-0” x 1’-0” Concrete Pads. 3000 psi compressive strength at 28 days.
Material:	Type II Concrete #3 Rebar at 12-in. on center each way placed in the center of the pad. HILTI HIT-HY 100 Adhesive Anchoring System (Three) ½-in. Hilti HAS-R Anchors x 6.5-in. lg (0.8mm) (Three) ½-in. Hilti HAS-R Anchors x 8.5-in. lg (3.0mm) (Six) 6”x6”x 2” spacer plates (3.0mm)
Performance:	N/A
Packaging, Shipping, and Storage:	Materials shall be inspected upon receipt for damage.
Electrical Requirements:	N/A
Documentation:	N/A
Codes, Standards, and/or Regulations:	ACI 318-14
Installation:	Pilot wedgewire screens tripods shall be fastened to concrete pad on site prior to placement at its location in the river.
Testing and Inspections:	N/A

COMPONENT SPECIFICATION #008

Requirements for Pump & Motor Concrete Pad

A pre-cast concrete pad was procured to support the pump and motor for the pilot wedgewire screens. This is to allow the pump and motor to sit leveled on a platform for it to function.

Design and Construction:	(Two) 2’-6” x 5’-0” x 6” Concrete Pad. 3000 psi compressive strength at 28 days.
Material:	Type II Concrete #3 Rebar at 12-in. on center each way placed in the center of the pad. HILTI HIT-HY 100 Adhesive Anchoring System (Eight) 5/8 in. Hilti Anchors x 4.5-in. leg Per Pad (Two) HSS 3.5” x 3.5” x 1/4” Per Pad (One) 3/8” x 1’-1”x 13 ½" plates Per pad
Performance:	N/A
Packaging, Shipping, and Storage:	Materials shall be inspected upon receipt for damage.
Electrical Requirements:	N/A
Documentation:	N/A
Codes, Standards, and/or Regulations:	ACI 318-14
Installation:	All steel and anchors shall be field installed on the concrete pad for a proper fit to mount the pump and motor.
Testing and Inspections:	N/A

COMPONENT SPECIFICATION #009

Requirements for Data Logger

A data logger was procured to record the raw data from the vacuum pressure gauges upstream of the test pumps. This data was used to decompose and quantify the clogging rate of the pilot wedgewire screens. The data logger was accessible for regular data transfers.

Design and Construction:	Handheld data logger with LCD display screen, SD card input and 3 channel input signal lead terminals. Able to store 2.7M readings on a 4 GB SD card in XLS format.
Material:	Primarily plastic case containing logic board and LCD screen.
Performance:	0 to 20 mA reading, 0.01 mA max resolution, ±(5% + 0.02mA) basic accuracy.
Packaging, Shipping, and Storage:	Materials shall be inspected upon receipt for damage. Included should be 6 AAA batteries, SD memory card, universal AC adaptor, 3 input connect sockets and mounting bracket.
Electrical Requirements:	Requires 120 VAC source.
Documentation:	Vendor user guide.
Codes, Standards, and/or Regulations:	ISO-9001, NIST traceable calibration
Installation:	Connect vacuum gauge terminals to input connect sockets. Store or mount data logger to dry, safe location.
Testing and Inspections:	If available, bench test a simple signal on each channel and check for proper writing to the SD card.

COMPONENT SPECIFICATION #010

Requirements for Variable Frequency Drive

Variable frequency drives were procured to control the test pump motors via pulse width modulation. The drives were programable for a spectrum alternating current frequencies corresponding to a range of pump speeds. The drives interfaced with the vacuum gauges to allow for automatic shutdown of the pumps on a low head scenario due to screen clogging.

Design and Construction:	Directly mountable, fully contained alternating current drive with accessible electrical output connection points.
Material:	Shall be constructed of durable materials resistant to expected environmental wear. Internal heatsink shall be capable of processing associated heat loads and retaining performance during cyclical use. NEMA rated 4X enclosure suggested.
Performance:	Capable of sustaining 20 horsepower steady state output. Requires frequency range of at least up to 300 Hz. To be run at or above 30 Hz for motor heat dissipation.
Packaging, Shipping, and Storage:	Materials shall be inspected upon receipt for damage.
Electrical Requirements:	Requires 480 VAC three phase power source.
Documentation:	Vendor user guide.
Codes, Standards, and/or Regulations:	UL 508A, UL 508C, IEEE 519
Installation:	Mount close to test pump motor. Install leads from 480 VAC power source. Ground the drive per manufacturer recommendations. Install leads from drive to pump motor. Install leads from vacuum gauge to drive.
Testing and Inspections:	Test as a part of all loop flow and pump testing.

Bill of Materials for Schiller Station Confirmatory Study							
Item #	**Dwg. BOM #**	**Quantity**	**Component Description**	**Specification No.**	**Potential Vendor**	**Vendor Part Number**	**Notes**
Test Sample Collection System (GSPL-00001-M-002-A)							
1	001	1	T-12HC Z-Alloy Wedgewire Test Screen, 0.8 mm Slot Width, and Carbon Steel Support Stand	001	Johnson Screens	T-12HC	wedgewire testing screen and support stand
2	035	1	T-12HC Z-Alloy Wedgewire Test Screen, 3.0 mm Slot Width, and Carbon Steel Support Stand	001	Johnson Screens	T-12HC	wedgewire testing screen and support stand, existing
3	002	4	6" PVC Suction Water Hose with Aluminum Cam-and-Groove Fittings, 100 ft.	002	McMaster-Carr	5293K51	Suction hose between screen and pump
4	002	2	6" PVC Suction Water Hose with Aluminum Cam-and-Groove Fittings, 30 ft.	002	McMaster-Carr	5293K51	Suction hose between screen and pump
5	003	2	6" Anodized Aluminum Cam-and-Groove Hose Plug Coupling with NPT Female End	-	McMaster-Carr	2084T59	Cam-lock fitting for suction hose
6	027	2	6" Anodized Aluminum Cam-and-Groove Hose Socket Coupling with NPT Male End	-	McMaster-Carr	2084T19	Cam-lock fitting for suction hose
7	004	4	6" Standard-Wall Unthreaded PVC Pipe, 10 ft.	002	McMaster-Carr	48925K45	PVC pipe run for flow meter and vacuum pressure gage
8	005	2	Digital Vacuum Gauge with switch	003	Instrumart	302274SD02LXAOU130/0IMV	Pressure gauge with digital readout. Male thread, requires tap. Programable trip switch for auto shutoff.
9	006	4	6" Pipe Size x 11" OD PVC Easy Align Unthreaded Pipe Flange, ANSI Class 150	-	McMaster-Carr	4881K241	Flange for connecting PVC piping to pump suction and discharge
10	007	2	6" Self Priming Trash Pump with Motor	004	R. C. Worst	SH6-U	Sampling pump
11	-	1	5310 Sealed Bearing	006	VBX	5310-2RS	Replacement sealed bearing for 2nd Pump
12	-	1	6310 Sealed Bearing	006	VBX	6310-2RS	Replacement sealed bearing for 2nd Pump
13	008	4	6" x 4" Standard-Wall PVC Reducer, Socket Female Connectors	-	McMaster-Carr	4880K688	Reducer on pump discharge
14	009	2	4" PVC Discharge Water Hose with Aluminum Cam-and-Groove Fittings, 25 ft.	002	McMaster-Carr	5295K38	Discharge hose from the pump to the screenhouse platform
15	009	2	4" PVC Discharge Water Hose with Aluminum Cam-and-Groove Fittings, 25 ft.	002	McMaster-Carr	5295K38	Discharge hose between pipe tees for bypass line

Bill of Materials for Schiller Station Confirmatory Study

Item #	Dwg. BOM #	Quantity	Component Description	Specification No.	Potential Vendor	Vendor Part Number	Notes
16	009	2	4" PVC Discharge Water Hose with Aluminum Cam-and-Groove Fittings, 50 ft.	002	McMaster-Carr	5295K38	Discharge hose from the tank to the screenwash trough
17	010	12	4" NPT Female Chrome-Plated Brass Ball Valve with Lockable Lever Handle	-	McMaster-Carr	4749K23	Ball valves for controlling the flow split between the tank/bypass flow and back flush cross-tie
18	011	2	GF Signet 2551 Magmeter	005	Instrumart	3-2551-P1-41	Flow meter with digital readout for 6" PVC Pipe, Pumps
19	012	6	4" x 4" x 4" Standard-Wall PVC Pipe Tee, Socket Female Connectors	-	McMaster-Carr	4880K48	PVC tee section to divide flow between the tank and the bypass
20	013	4	4" Anodized Aluminum Cam-and-Groove Hose Plug Coupling with NPT Male End	-	McMaster-Carr	2084T48	Cam-lock fitting for discharge hose
21	018	4	4" Anodized Aluminum Cam-and-Groove Hose Socket Coupling with NPT Male End	-	McMaster-Carr	2084T18	Cam-lock fitting for discharge hose
22	023	8	4" Anodized Aluminum Cam-and-Groove Hose Plug Coupling with NPT Female End	-	McMaster-Carr	2084T58	Cam-lock fitting for discharge hose
23	014	2	6" Standard-Wall PVC Pipe Adaptor, Socket Female x NPT Female	-	McMaster-Carr	4880K151	Adaptor for connecting 6" cam-lock fitting to 6" PVC pipe run
24	015	16	4" Standard-Wall PVC Pipe Adaptor, Socket Female x NPT Male	-	McMaster-Carr	4880K68	Adaptor for connecting 4" PVC tee to the flow control ball valves
25	016	2	4" Standard-Wall Unthreaded PVC Pipe, 10 ft.	002	McMaster-Carr	48925K18	PVC pipe run for flow meter prior to sampling tank and for run up to the top of the tank
26	017	2	480V, Three-Phase, 20 HP VFD Controller in NEMA 4X Enclosure		Weg	CFW080300TGN4A1Z	VFD controller to operate motor pump
27	019	2	4" NPT Threaded Galvanized Steel Pipe Nipple, 4" Long	-	McMaster-Carr	4549K905	Pipe nipple to connect sampling tank outlet to ball valve
28	020	4	6" Standard-Wall PVC Socket Connector, Male	-	McMaster-Carr	4880K131	PVC piping socket connector for joining the PVC pipes
29	021	4	6" ANSI Class 150 Gasket, 1/16" Thick	-	McMaster-Carr	9472K643	Gasket for the flanges on the pump suction and discharge
30	022	2	6" NPT Threaded Steel Pipe Nipple, 8" Long	-	McMaster-Carr	44615K185	Steel pipe that is cut and butt welded to connect the screen elbow to the cam lock
31	023	2	4" Standard-Wall PVC Pipe Adaptor, Socket Female x NPT Female		McMaster-Carr	4880K88	Adaptor for connecting 4" cam-lock fitting to 4" PVC pipe run
32	028	6	4" Standard-Wall PVC 90-Degree Long Elbow Connector, Female Socket Connectors	-	McMaster-Carr	2389K115	Long 90-degree pipe elbows to construct the "U" shaped inlet into the sampling tank

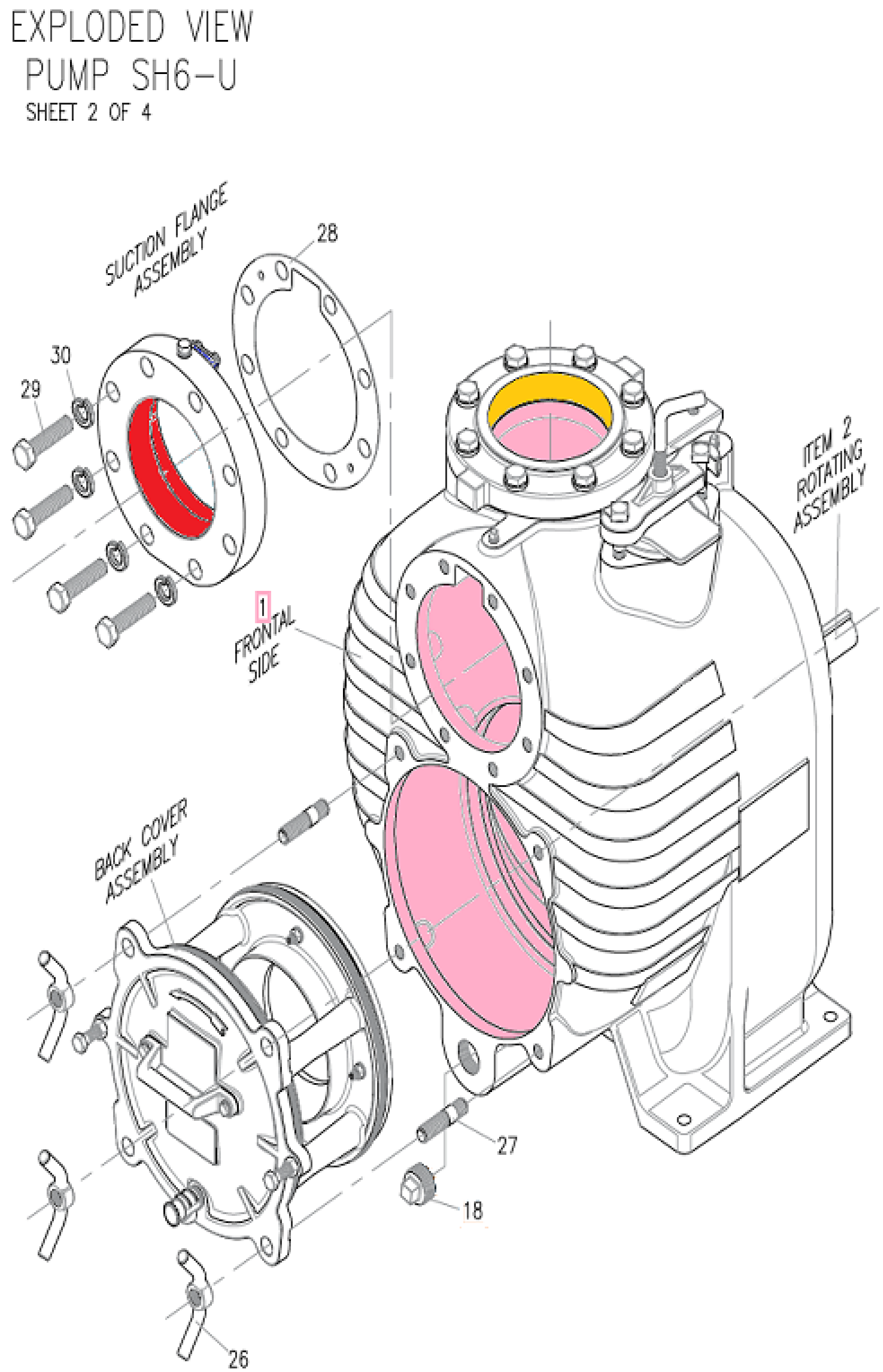
Bill of Materials for Schiller Station Confirmatory Study

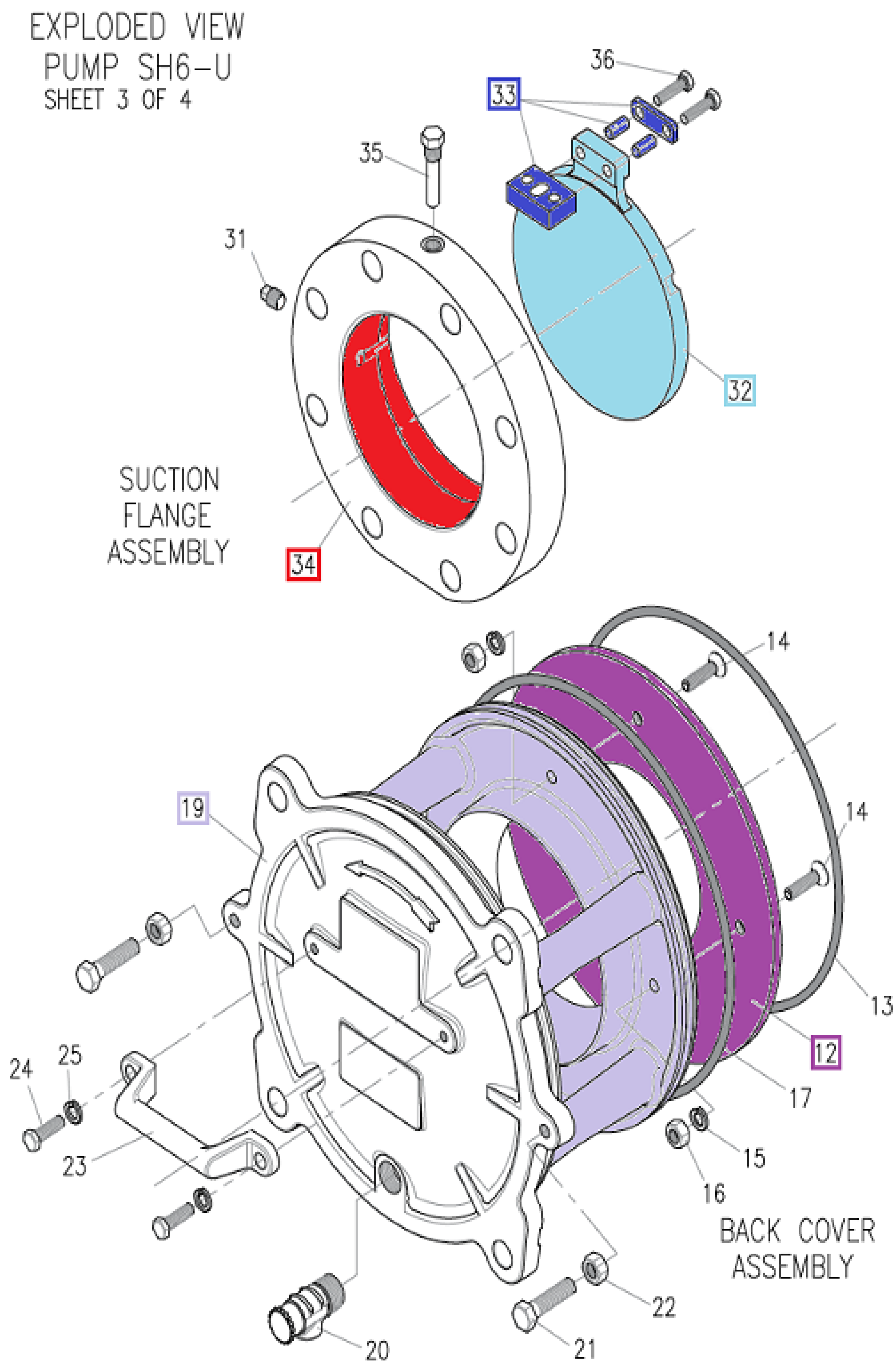
Item #	Dwg. BOM #	Quantity	Component Description	Specification No.	Potential Vendor	Vendor Part Number	Notes
33	029	2	Plastic Routing Clamp for 4" Pipe Size, Pack of 5	-	McMaster-Carr	3192T59	Clamps to restrain the vertical PVC piping against the sampling tank
34	030	2	High-Pressure Clamp-on Connector for 6" Pipe Size	-	McMaster-Carr	5542K63	High-pressure clamp-on connector to join steel pipe to Z-alloy screen outlet
35	031	2	GF Signet 2551 Magmeter	005	Instrumart	3-2551-P0-41	Flow meter with digital readout for 4" PVC Pipe, Tanks
36	024	2	26-inch penetrators with 24" tie-off cables, set of 12	-	AmericanEarthAnchors	PE26-TC-B12	Underwater anchors to tie down the suction hose; 9-inches additional length per cable at additional $0.75 per cable
37	-	1	Ratcheting T-handle for penetrator installation	-	AmericanEarthAnchors	PE-RTH	underwater anchor installation tool
38	033	2	3/8" Thick A36 Steel Plate, 13" x 13.5"	-	MetalsDepot	P138	Steel plate that bridges the two H beams, creating a platform to support the pump motor (custom cut)
39	032	4	3-1/2" x 3-1/2" x 1/4" Wall A500 Square Steel Tube, 1'-1" Long	-	MetalsDepot	T131214	Square steel tubes to elevate and align the pump motor
40	-	1	1/8" NPT Thread Tap, Uncoated High-Speed Steel	-	McMaster-Carr	2525A169	Tap to cut threads in the PVC pipe for the pressure gauge
41	-	4	3/4"-10 Alloy Zinc-Plated Hex Head Screw, 4.5" Long, Pack of 5	-	McMaster-Carr	91247A853	Bolts for the pump flanges and to anchor the pump skid to the platform
42	-	1	3/4"-10 Medium-Strength Zinc-Plated Steel Hex Nuts, Pack of 25	-	McMaster-Carr	95462A538	Flange locknuts for the flanges on the pump suction and discharge and pump skid
43	-	2	Zinc Yellow-Chromate Plated Grade 8 Steel Washer for 3/4" Screw, Pack of 20	-	McMaster-Carr	98023A036	Washers for the flanges on the pump suction and discharge and pump skid
44	-	1	Pipe Cement for PVC Plastic Pipe, Max Pipe Diameter of 6" 16 oz.	-	McMaster-Carr	74605A14	PVC glue for joining piping and fittings
45	-	1	Pipe Thread Sealant Tape, 1/2" Wide	-	McMaster-Carr	6802K12	Teflon tape for pipe and fitting connections
46	025	2	GF Signet 4" PVC Saddle Installation Fitting	-	Instrumart	PV8S040	Saddle installation fitting for 4" pipe flow meter
47	026	2	GF Signet 6" PVC Saddle Installation Fitting	-	Instrumart	PV8S060	Saddle installation fitting for 6" pipe flow meter
48	-	4	GF Signet 7310 Switching Power Supply, 24 V DC, 0.42 A Output	005	Instrumart	7310-1024	Power supply for the flow meter
49	-	150	14 AWG, 3/C Harsh Environment Cable 1' Long	-	McMaster-Carr	8248K17	Cable to supply power to the power supplies, and then to the flow meters
50	-	2	Vibration-Resistant Worm-Drive Clamps for 6" Hose, Stainless Steel, Pack of 2	-	McMaster-Carr	5661K21	Hose clamps to secure bypass discharge hose on railing above the Outfall 004 piping

Bill of Materials for Schiller Station Confirmatory Study							
Item #	**Dwg. BOM #**	**Quantity**	**Component Description**	**Specification No.**	**Potential Vendor**	**Vendor Part Number**	**Notes**
Control Sample Collection System (GSPL-00001-M-003-A)							
51	-	8	1/2"-13 x 2" HHB Grade B7, Each	-	McMaster-Carr	94705A209	Bolts to secure the motor to square stock
52	-	1	Zinc Yellow-Chromate Plated Grade 8 Steel Washer for 1/2" Screw, Pack of 25	-	McMaster-Carr	98023A033	Washers for motor to square stock
53	-	1	1/2"-13 Locknut, Pack of 25	-	McMaster-Carr	90652A050	Locknut for motor plate assembly.
54	-	16	5/8"-11 x 4.5" Grade B7 Threaded Rod, Single	-	McMaster-Carr	98750A218	Bolts to secure the pump/motor base assembly to the concrete pad
55	-	1	Zinc Yellow-Chromate Plated Grade 8 Steel Washer for 5/8" Screw, Pack of 25	-	McMaster-Carr	98023A035	Washers for pump/motor anchor bolts
56	-	1	5/8"-11 Hex Nut Grade 5, Pack of 25	-	McMaster-Carr	95462A533	Nuts for pump/motor anchor bolts
57	-	2	Anchor adhesive	-	Hilti	2078494	Includes foil pack, mixer and mixer extension
58	-	1	Adhesive Applicator	-	Hilti	HDM	Applicator for Anchor Adhesive, also used for Screen Pads
59	-	2	2'-6" x 5'-0" x 6" Pre-Cast Concrete Pad	008	Shea Concrete	Quote 49853	Concrete Pad for Pump/Motor, Delivery extra
60	036	1	Data Logger	009	Instrumart	SD900	Record Data from Vacuum Pressure Meter
61	034	2	6" x 6" x 6" Standard-Wall PVC Pipe Tee, Socket Female Connectors	-	McMaster-Carr	480K121	6" Tee to connect back flush cross tie to suction side of pump
62	037	2	4" x 4" x 4" Standard-Wall PVC Pipe Tee, Socket Female Connectors x NPT Female	-	McMaster-Carr	4880K401	4" Tee with threaded branch to serve as a drain for piping leading to collection tank
63	038	2	4" PVC NPT Male Plug with External Square Drive Style	-	McMaster-Carr	2389K81	4" threaded drain plug to block drain for piping leading to collection tank
64	102	50	3" High Pressure Easy Store Discharge Water Hose, per ft.	-	McMaster-Carr	45845K5	Discharge layflat hose for draining collection tank to riff-raff
65	103	1	4" Anodized Aluminum Cam-and-Groove Hose Plug Coupling with NPT Male End	-	McMaster-Carr	2084T48	Cam-lock fitting for discharge hose
66	111	1	4" Anodized Aluminum Cam-and-Groove Hose Socket Coupling with NPT Male End	-	McMaster-Carr	2084T18	Cam-lock fitting for discharge hose
67	105	2	4" Socket Male X 4" NPT Female Standard Wall PVC Adaptor	-	McMaster-Carr	2389K95	Adaptor for connecting 3" PVC pipe to the discharge hose

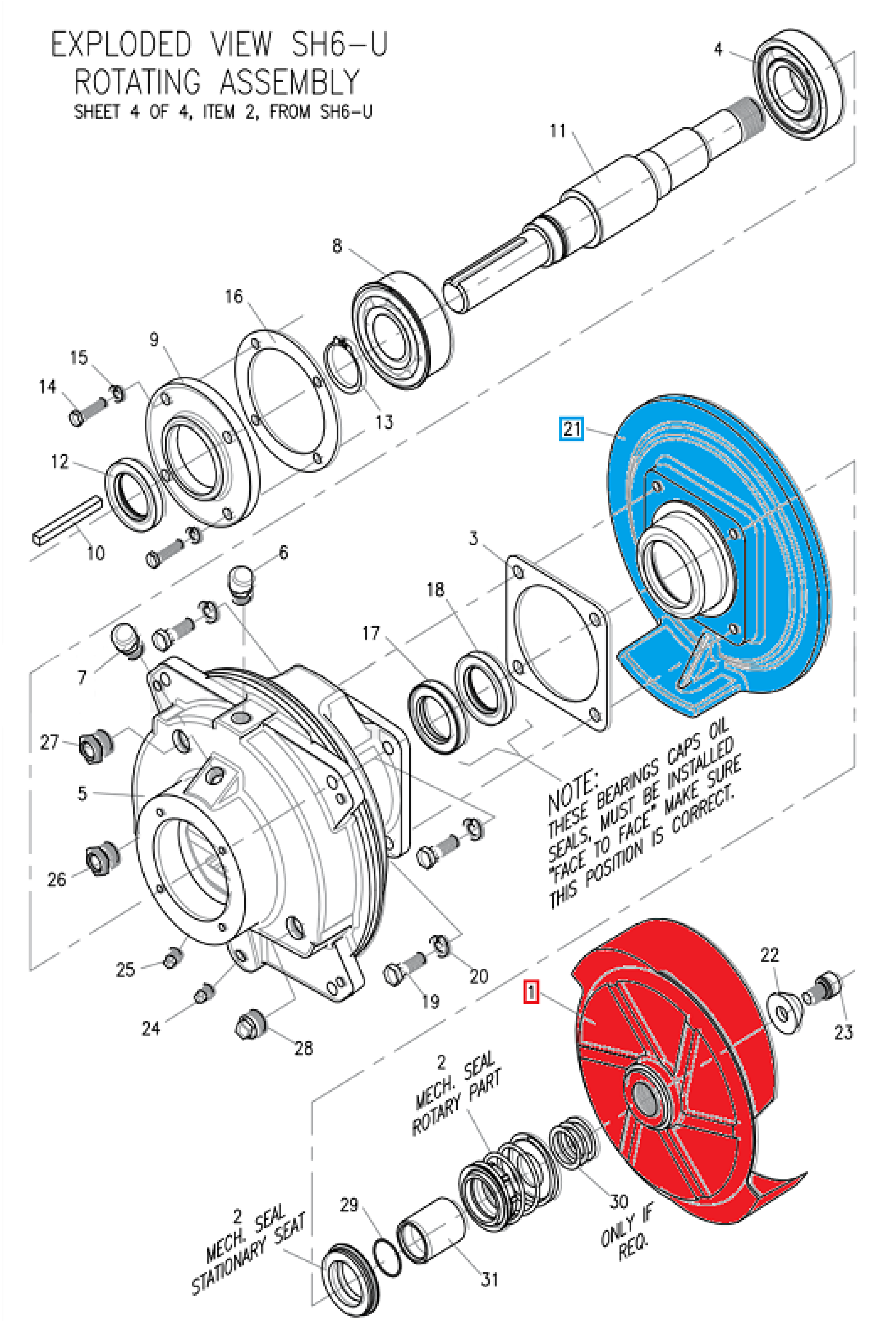
Bill of Materials for Schiller Station Confirmatory Study							
Item #	**Dwg. BOM #**	**Quantity**	**Component Description**	**Specification No.**	**Potential Vendor**	**Vendor Part Number**	**Notes**
0.8mm Wedgewire Screen and Tripod Support (GSPL-00001-SK-001-A)							
68	106	2	4" Standard-Wall Unthreaded PVC Pipe, 10 ft.	002	McMaster-Carr	48925K18	PVC pipe run from the discharge hose to the sampling tank
69	107	1	GF Signet 2551 Magmeter	005	Instrumart	3-2551-P0-41	Flow meter with digital readout for 4" PVC pipe
70	109	3	4" Standard-Wall PVC 90-Degree Long Elbow Connector, Female Socket Connectors	-	McMaster-Carr	2389K115	Long 90-degree pipe elbows
71	110	1	Plastic Routing Clamp for 4" Pipe Size, Pack of 5	-	McMaster-Carr	3192T59	Clamps to restrain the vertical PVC piping against the sampling tank
72	-	1	GF Signet 7310 Switching Power Supply, 24 V DC, 0.42 A Output	005	Instrumart	7310-1024	Power supply for the flow meter
73	-	200	14 AWG, 3/C Harsh Environment Cable 1' Long	-	McMaster-Carr	8248K17	Cable to supply power to the power supply, and then to the flow meters
74	112	1	GF Signet 4" PVC Saddle Installation Fitting	-	Instrumart	PV8S040	Saddle installation fitting for 3" pipe flow meter
75	-	1	Pipe Cement for PVC Plastic Pipe, Max Pipe Diameter of 6" 16 oz.	-	McMaster-Carr	74605A14	PVC glue for joining piping and fittings
76	-	1	Pipe Thread Sealant Tape, 1/2" Wide	-	McMaster-Carr	6802K12	Teflon tape for pipe and fitting connections
77	113	1	4" PVC Discharge Water Hose with Aluminum Cam-and-Groove Fittings, 10 ft.	002	McMaster-Carr	45815K28	Suction hose from the sampling port to the PVC piping
78	114	1	4" x 4" x 4" Standard-Wall PVC Pipe Tee, Socket Female Connectors x NPT Female	-	McMaster-Carr	4880K401	4" Tee with threaded branch to serve as a drain for piping leading to collection tank
79	115	1	4" PVC NPT Male Plug with External Square Drive Style	-	McMaster-Carr	2389K81	4" threaded drain plug to block drain for piping leading to collection tank
80	001	1	Nylon caps-3" inner height, 0.08" thick walls, Pack of 10	-	McMaster-Carr	40005K36	Non-conductive sleeve
81	002	3	Coupler-304 SS rod, 1.75"x6"	-	McMaster-Carr	9210K25	machined on site from stock
82	003	3	A400 bolt, 1/2"-13 x 2.5", Each	-	McMaster-Carr	90780A722	Bolt the coupler to z-alloy stub on screen
83	004	3	A400 nut, 1/2"-13, Each	-	McMaster-Carr	90810A033	Nut for bolting coupler to z-alloy stub on screen
84	005	1	SS bolt, 3/8"x2.5", pack of 10	-	McMaster-Carr	92198A634	Bolt the coupler to SS leg on tripod
85	006	1	SS nut, 3/8", pack of 25	-	McMaster-Carr	92673A125	Nut for bolting coupler to SS leg on tripod
86	007	1	Vinyl washers, 0.355" ID, 0.812" OD, pack of 25	-	McMaster-Carr	99604A123	Non-conductive washer between bolt and coupler
87	008	6	Polypropylene Unthreaded Spacer for 1/2" screw	-	McMaster-Carr	95136A350	Non-conductive sleeve between bolt and tripod leg/stub

Bill of Materials for Schiller Station Confirmatory Study							
Item #	**Dwg. BOM #**	**Quantity**	**Component Description**	**Specification No.**	**Potential Vendor**	**Vendor Part Number**	**Notes**
88	009	1	SS304 tripod leg, 6' length	-	McMaster-Carr	89535K45	3 x 1'-5/16" legs required, 1-1/4" OD stock, machined to 1" OD
89	010	1	SS304 HAS-R 1/2"x6.5" Anchor Rod, pack of 20	-	Hilti	385464	Includes threaded rod, nut and washer
90	011	1	Anchor adhesive	-	Hilti	2078494	Includes foil pack, mixer and mixer extension
91	012	3	3/16” thick 6”x6” stainless steel plate	-	MetalsDepot	P178	Spacer for the 0.8mm screen footings to allow the elbow to run above the concrete
92	013	1	3' x 3' x 1' precast concrete pad	007	Shea Concrete	Quote 49853	Screen Concete pad, delivery extra
92	014	1	Vinyl washers, 0.49" ID, 1.062" OD, pack of 25	-	McMaster-Carr	99604A125	Non-conductive washer between bolt and coupler
3.0mm Wedgewire Screen and Tripod Support (GSPL-00001-SK-002-A)							
93	001	1	Nylon caps-3" inner height, 0.08" thick walls, Pack of 10	-	McMaster-Carr	40005K36	Non-conductive sleeve
94	002	3	Coupler-304 SS rod, 1.75"x6"	-	McMaster-Carr	9210K25	machined on site from stock
95	003	3	A400 bolt, 1/2"-13 x 2.5", Each	-	McMaster-Carr	90780A722	Bolt the coupler to z-alloy stub on screen
96	004	3	A400 nut, 1/2"-13, Each	-	McMaster-Carr	90810A033	Nut for bolting coupler to z-alloy stub on screen
97	005	See Note	SS bolt, 3/8"x2.5", pack of 10	-	McMaster-Carr	92198A634	Purchasing covered under BOM for GSPL-00001-SK-001-A
98	006	See Note	SS nut, 3/8", pack of 25	-	McMaster-Carr	92673A125	Purchasing covered under BOM for GSPL-00001-SK-001-A
99	007	See Note	Vinyl washers, 0.355" ID, 0.812" OD, pack of 25	-	McMaster-Carr	99604A123	Purchasing covered under BOM for GSPL-00001-SK-001-A
100	008	6	Polypropylene Unthreaded Spacer for 1/2" screw	-	McMaster-Carr	95136A350	Non-conductive sleeve between bolt and tripod leg/stub
101	009	See Note	SS304 tripod leg, 6' length	-	McMaster-Carr	89535K45	3 x 10-1/8" legs required, 1-1/4" OD stock, machined to 1" OD, purchasing covered under BOM for GSPL-00001-SK-001-A
102	010	1	SS304 HAS-R 1/2"x10" anchor rods, pack of 10	-	Hilti	385466	Includes threaded rod, nut and washer
103	011	See Note	Anchor adhesive	-	Hilti	2078494	Purchasing covered under BOM for GSPL-00001-SK-001-A
104	012	6	3/16" thick 6"x6" stainless steel plate	-	MetalsDepot	P178	Spacer for the 3.0mm screen footings to allow the elbow to run above the concrete
105	013	1	3' x 3' x 1' precast concrete pad	008	Shea Concrete	Quote 49853	Screen Concete pad, delivery extra
106	014	See Note	Vinyl washers, 0.49" ID, 1.062" OD, pack of 25	-	McMaster-Carr	99604A125	Purchasing covered under BOM for GSPL-00001-SK-001-A


EXPLODED VIEW
PUMP SH6-U
SHEET 2 OF 4
SUCTION FLANGE ASSEMBLY
28
30
29
ITEM 2 ROTATING ASSEMBLY
1
FRONTAL SIDE
BACK COVER ASSEMBLY
27
18
26

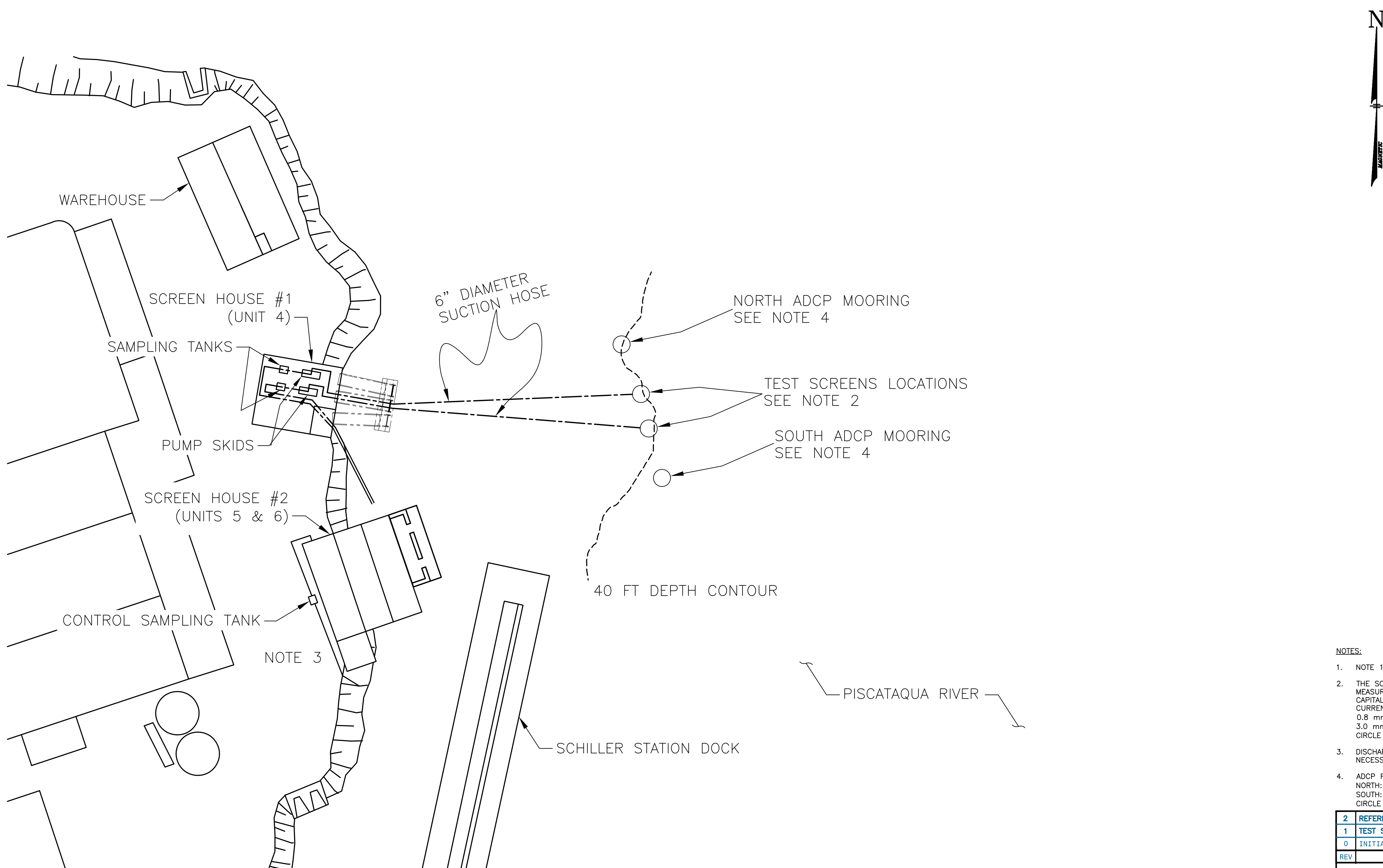

EXPLODED VIEW
PUMP SH6-U
SHEET 3 OF 4
36
33
35
31
32
SUCTION
FLANGE
ASSEMBLY
34
14
14
19
13
12
17
24
25
15
23
16
BACK COVER
ASSEMBLY
22
20
21

PART LIST			
ITEM	QTY.	DESCRIPTION	PART No.
1	1	PUMP CASING	03090076
2	1	REPAIR ROTATING ASSY. (SEE: SH6 ROTATING ASSEMBLY PART LIST)	
3	1	PIPE PLUG	93010143
4	1	DISCHARGE FLANGE	03060008
5	1	DISCHARGE FLANGE GASKET	92010159
6	8	HEX HEAD CAPSCREW	91010292
7	8	LOCKWASHER	91010016
8	1	O–RING, ROTATING ASSEMBLY	92010047
9	4	HEX HEAD CAPSCREW	91010263
10	4	LOCKWASHER	91010014
11	12	ROTATING ASSEMBLY ADJ SHIM SET	91010057
12	1	WEAR PLATE ASSY	30400855
13	1	BACK COVER O–RING	92010048
14	4	CONICAL SCREW	91010402
15	4	LOCKWASHER	91010061
16	4	HEX NUT	91010433
17	1	BACK COVER O–RING	92010047
18	1	CASING DRAIN PLUG	93010146
19	1	BACK COVER PLATE ASSY.	03220021
20	1	PRESS RELIEF VALVE	31200021
21	2	JACK BOLT – BACK COVER	91010264
22	2	JAM NUT – BACK COVER	91010415
23	1	COVER PLATE HANDLE	03151002
24	2	HEX HEAD CAPSCREW	91010244
25	2	LOCKWASHER	91010012
26	4	HAND NUT	03230002
27	4	STUD	91010321
28	1	SUCTION FLANGE GASKET	92010178
29	8	HEX HEAD CAPSCREW	91010293
30	8	LOCKWASHER	91010016
31	1	PIPE PLUG	93010143
32	1	SUCTION CHECK VALVE	92010225
33	1	SUPPORT	30400890
34	1	SUCTION FLANGE	03050015
35	1	CHECK VALVE PIN	30400867
36	2	HEX HEAD CAPSCREW	91010224
37	1	CLAMP BAR SCREW	30400911
38	1	PIPE PLUG	93010143
39	1	CLAMP BAR	03040501
40	2	MACHINE BOLT	91010401
41	1	FILL COVER PLATE	03220022
42	1	COVER GASKET	92010124
43	1	PIPE PLUG	93010142


EXPLODED VIEW SH6-U
ROTATING ASSEMBLY
SHEET 4 OF 4, ITEM 2, FROM SH6-U
NOTE:
THESE BEARINGS CAPS OIL SEALS, MUST BE INSTALLED "FACE TO FACE" MAKE SURE THIS POSITION IS CORRECT.
2 MECH. SEAL ROTARY PART
2 MECH. SEAL STATIONARY SEAT
ONLY IF REQ.

PART LIST			
ITEM	QTY.	DESCRIPTION	PART No.
1	1	IMPELLER	03140072
2	1	MECHANICAL SEAL (SEE NOTE: 1)	31030403
3	1	SEAL PLATE GASKET	92010173
4	1	INBOARD BALL BEARING	31020030
5	1	BEARING HOUSING	03040022
6	1	AIR VENT	80062501
7	1	AIR VENT	80062501
8	1	OUTBOARD BEARING	31020029
9	1	BEARING CAP	03170013
10	1	SHAFT KEY	30400634
11	1	IMPELLER SHAFT	30400755
12	1	BEARING CAP OIL SEAL	31150009
13	1	BEARING SNAP RING	31010013
14	4	HEX HEAD CAPSCREW	91010244
15	4	LOCKWASHER	91010012
16	1	BEARING CAP GASKET	92010166
17	1	INBOARD OIL SEAL	31150009
18	1	INBOARD OIL SEAL	31150009
19	4	HEX HEAD CAPSCREW	91010263
20	4	LOCKWASHER	91010014
21	1	SEAL PLATE	03180024
22	1	IMPELLER WASHER	30400425
23	1	SOCKET HEAD CAPSCREW	91010395
24	1	SEAL CAVITY DRAIN PLUG	93010143
25	1	BEARING HOUSING DRAIN PLUG	93010143
26	1	SIGHT GAUGE	31120012
27	1	SIGHT GAUGE	31120012
28	1	PIPE PLUG	93010148
29	1	SEAL SLEEVE O-RING	92010036
30	3	IMPELLER ADJ SHIM SET	30400401
31	1	SEAL SLEEVE	30400825

NOTE:
1.- THE MECHANICAL SEAL, IS AVAILABLE IN TUNGSTEN FACES; IN THIS CASE THE PART NUMBER IS # 31030404.



NOTES:

1. NOTE 1 NOT USED.

2. THE SCREEN LOCATIONS ARE BASED ON ADCP CURRENT DATA MEASURED PRIOR TO DEPLOYMENT AND WERE SELECTED TO CAPITALIZE ON STRONG, DIRECTIONALLY CONSISTENT CURRENTS. FINAL LOCATIONS OF THE TEST SCREENS ARE:
   0.8 mm: 43°05'53.22"N, 70°46'56.76"W
   3.0 mm: 43°05'53.04"N, 70°46'56.64"W
   CIRCLE INDICATES A GPS COORDINATE ACCURACY OF 5'3".

3. DISCHARGE PIPE ROUTING IS SUGGESTED. FIELD–ROUTE AS NECESSARY TO REACH SHORELINE AREA.

4. ADCP FINAL LOCATIONS ARE:
   NORTH: 43°05'53.48"N, 70°46'57.00"W
   SOUTH: 43°05'52.77"N, 70°46'56.46"W
   CIRCLE INDICATES A GPS COORDINATE ACCURACY OF 5'3".

REV	DESCRIPTION	DRN	CHK	REV	APP	DATE
2	REFERENCE DIMESNIONS					
1	TEST SCREEN LOCATION					
0	INITIAL ISSUE					

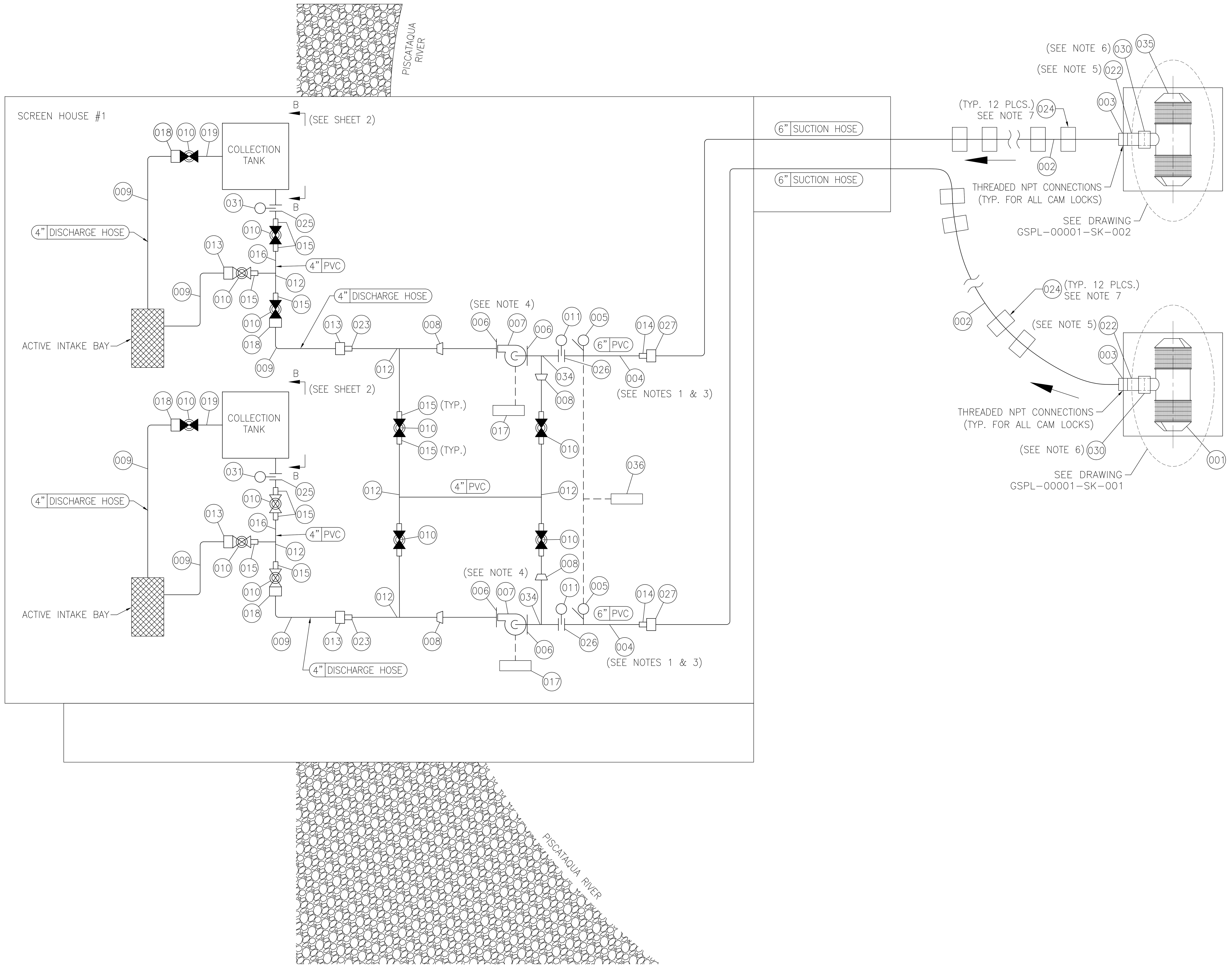
ENERCON
Oakland, CA 94621

GRANITE SHORE POWER LLC
SCHILLER STATION

SITE PLAN
TEST WEDGEWIRE SCREEN ASSEMBLIES

SIZE: D | DWG NO.: GSPL-00001-M-001 | REV: 2

SCALE: NONE | SHEET: 1 of 1



PLAN VIEW

NOTES:

1. UNLESS OTHERWISE NOTED, ALL PVC PIPING AND FITTINGS ARE CONNECTED USING SOCKET CONNECTORS, FIELD-TO-FIT CUT PIECES OF THE NOMINAL PVC PIPE SIZE AND PVC ADHESIVE.
2. FIELD TO FIT ALL ELECTRICAL CONNECTIONS.
3. SEPARATE SECTIONS OF PVC PIPE ARE CONNECTED USING A SOCKET CONNECTER, BOM ITEM 020.
4. 1/16" THICK, 6" ANSI CLASS 150 GASKETS, BOM ITEM 021, ARE INSTALLED BETWEEN THE FLANGE AND THE PUMP SUCTION/DISCHARGE.
5. CUT THE THREADED END OFF OF ONE SIDE OF THE NIPPLE, SO THAT ONE SIDE IS THREADED AND ONE IS NOT.
6. WHEN INSERTING THE Z-ALLOY AND STEEL PIPES INTO THE CONNECTOR, ENSURE THAT THE ENDS OF THE PIPES ARE NOT TOUCHING.
7. ANCHORS SHOULD BE EQUALLY SPACED ALONG THE PORTION OF THE HOSE RESTING ON THE RIVER BED.

REV	DESCRIPTION	DRN	CHK	REV	APP	DATE
0	INITIAL ISSUE					

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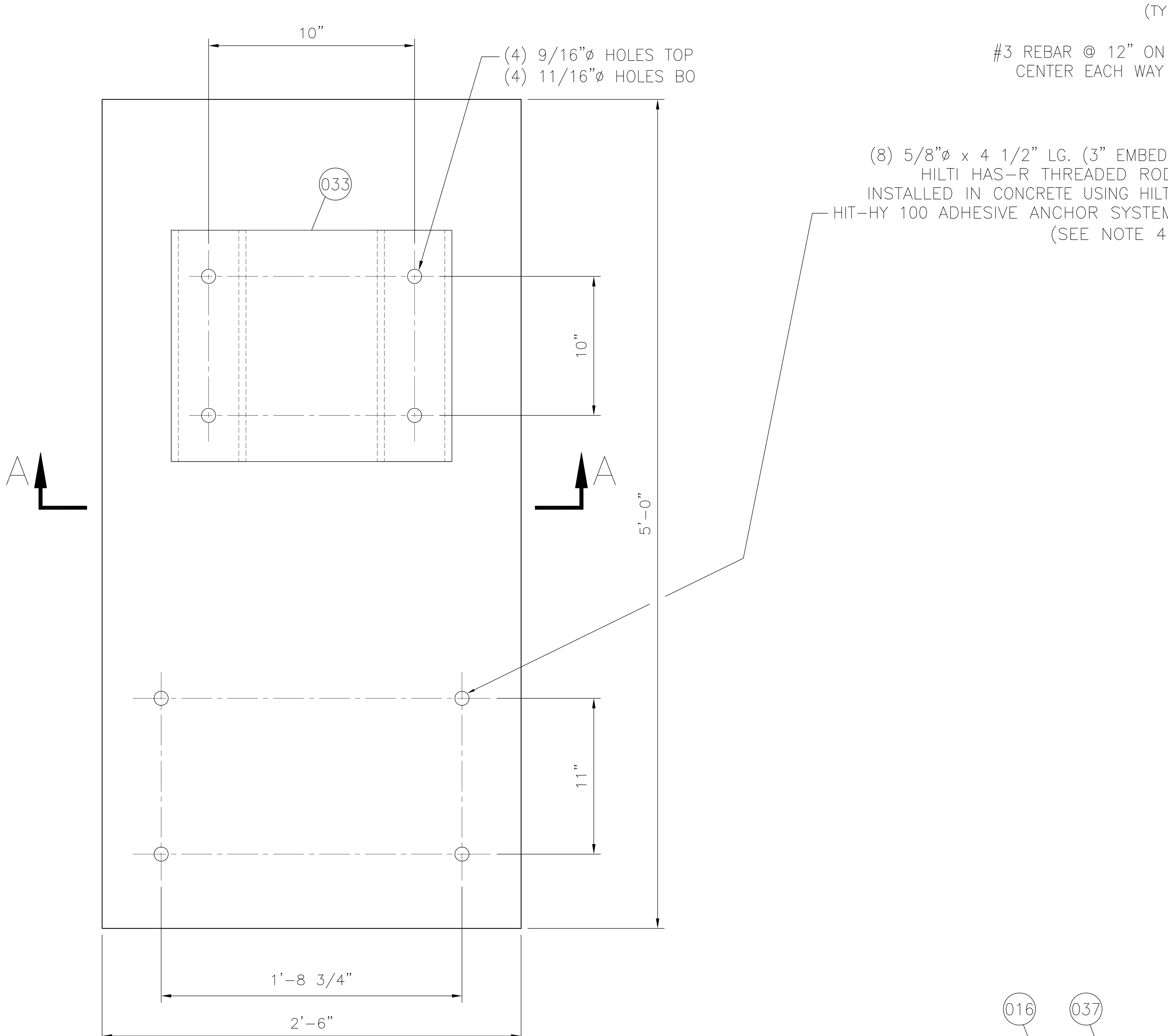
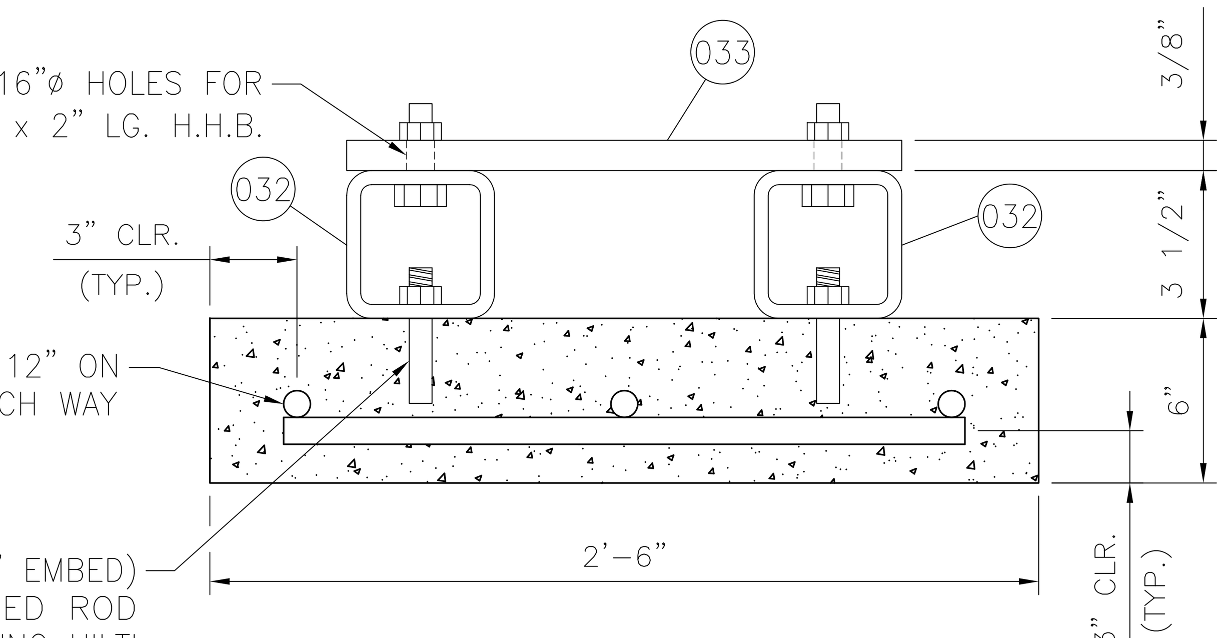
GRANITE SHORE POWER LLC
SCHILLER STATION

IN-RIVER TESTING
TEST SAMPLING LAYOUT

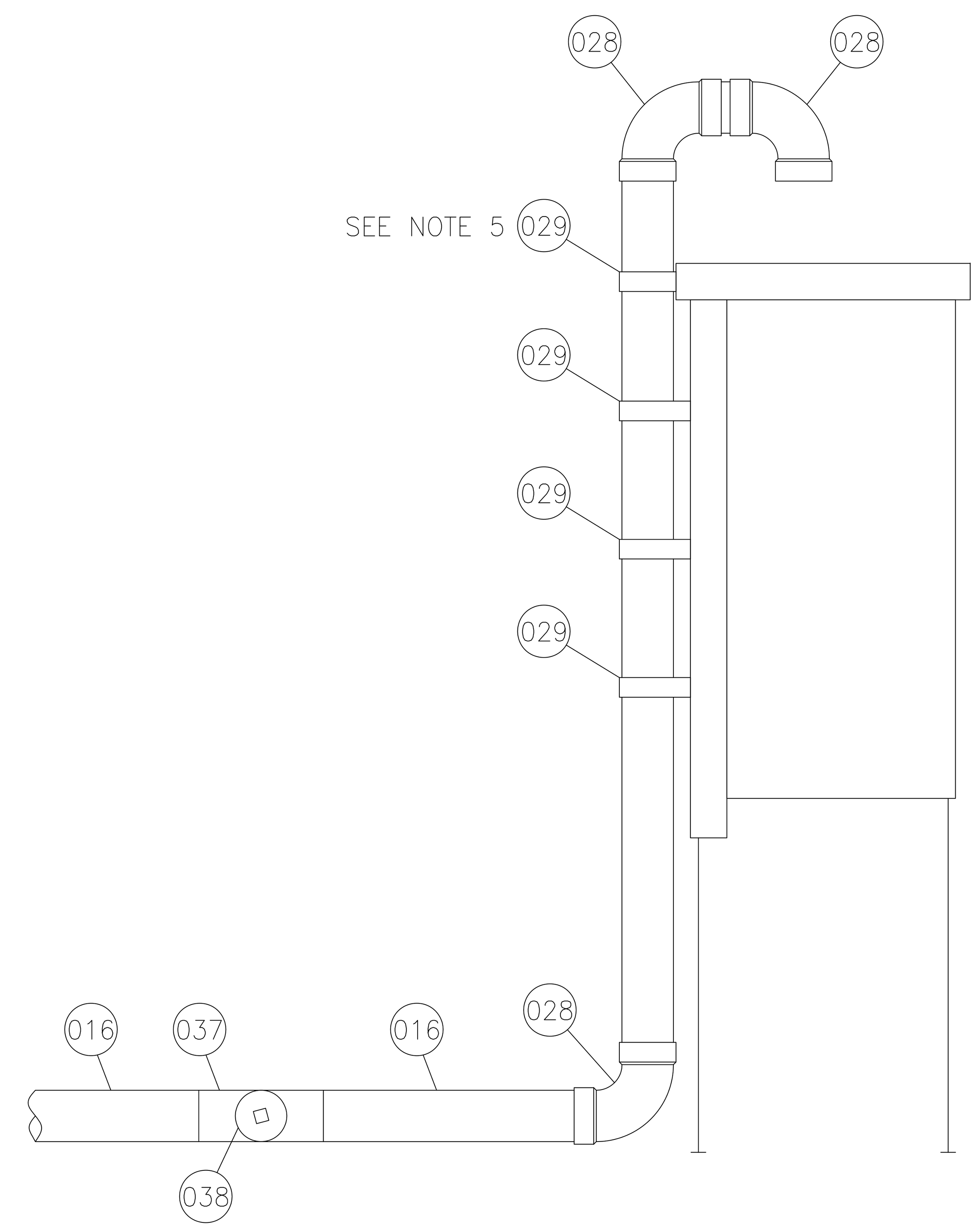
SIZE	DWG NO.	REV
D	GSPL-00001-M-002	0
SCALE	NONE	SHEET 1 of 2



PLAN VIEW



SECTION A–A



SECTION B–B

SEE SHEET 1

BILL OF MATERIALS			
NO.	QTY.	DESCRIPTION	SPEC. NO.
001	1	JOHNSON T–12 TEST SCREEN & STAND ASSEMBLY (GSPL–00001–SK–001)	001
002	–	6" SUCTION HOSE	002
003	2	6" ANODIZED ALUMINUM CAM–LOCK PLUG	–
004	–	6" PVC PIPING	002
005	2	ABSOLUTE PRESSURE GAUGE	003
006	4	6" PVC FLANGE	–
007	2	6" SELF PRIMING TEST PUMP	004
008	4	6"x4" PVC REDUCER	–
009	–	4" DISCHARGE HOSE	002
010	12	4" BRASS BALL VALVE, NPT FEMALE	–
011	2	6" FLOW METER	005
012	6	4"x4"x4" PVC PIPE TEE	–
013	4	4" ANODIZED ALUMINUM CAM–LOCK PLUG x NPT MALE	–
014	2	6" PVC ADAPTER, SOCKET FEMALE x NPT FEMALE	–
015	16	4" PVC ADAPTER, SOCKET FEMALE x NPT MALE	–
016	–	4" PVC PIPE	002
017	2	VFD CONTROLLER	–
018	4	4" ANODIZED ALUMINUM CAM–LOCK SOCKET x NPT MALE	–
019	2	4" NPT THREADED GALVANIZED STEEL PIPE NIPPLE, 4" LONG	–
020	4	6" STANDARD–WALL PVC SOCKET CONNECTOR	–
021	4	1/16" THICK 6" ANSI CLASS 150 GASKET	–
022	2	6" NPT THREADED STEEL PIPE NIPPLE, 8" LONG	–
023	2	4" PVC ADAPTER, SOCKET FEMALE X NPT FEMALE	–
024	24	PENETRATING EARTH ANCHOR	–
025	2	GF SIGNET 4" PVC SADDLE INSTALLATION FITTING	–
026	2	GF SIGNET 6" PVC SADDLE INSTALLATION FITTING	–
027	2	6" ANODIZED ALUMINUM CAM–LOCK SOCKET x NPT MALE	–
028	6	4" PVC 90–DEGREE LONG ELBOW CONNECTOR	–
029	8	PLASTIC ROUTING CLAMP FOR 4" PVC PIPE	–
030	2	HIGH–PRESSURE CLAMP–ON CONNECTOR FOR 6" PIPE	–
031	2	4" FLOW METER	–
032	4	3 1/2" x 3 1/2" x 1/4" WALL A500 SQUARE STEEL TUBE, 1'–1" LG.	–
033	2	PL 3/8" x 1'–1" x 13 1/2" LG.	–
034	2	6" x 6" x 6" PVC PIPE TEE	–
035	1	JOHNSON T–12 TEST SCREEN & STAND ASSEMBLY (GSPL–00001–SK–002)	001
036	1	DATA LOGGER	009
037	2	4" x 4" x 4" PVC PIPE TEE x NPT FEMALE	–
038	2	4" PVC NPT MALE PLUG	–

NOTES:

1. ALL TUBE STEEL SHALL BE ASTM A500, ALL OTHER SHAPES, PLATES, AND BARS (SQUARE AND ROUND) SHALL CONFORM TO ASTM A36 STEEL.
2. FIELD TO DRILL ALL BOLT HOLES FOR MOUNTING THE PUMP AND MOTOR.
3. CONCRETE PAD SHALL BE MADE UP OF TYPE II CONCRETE AND HAVE A MIN. COMPRESSIVE STRENGTH OF 3000 PSI @ 28 DAYS.
4. CONTRACTOR SHALL LOCATE HILTI ANCHORS IN THE FIELD TO ASSEMBLE THE PUMP AND MOTOR.
5. STARTING AT TOP OF TANK, INSTALL CLAMP EVERY 24" DOWN SIDE OF TANK.
6. REINFORCING STEEL SHALL BE ASTM A615, GRADE 60.

REV	DESCRIPTION	DRN	CHK	REV	APP	DATE
0	INITIAL ISSUE					

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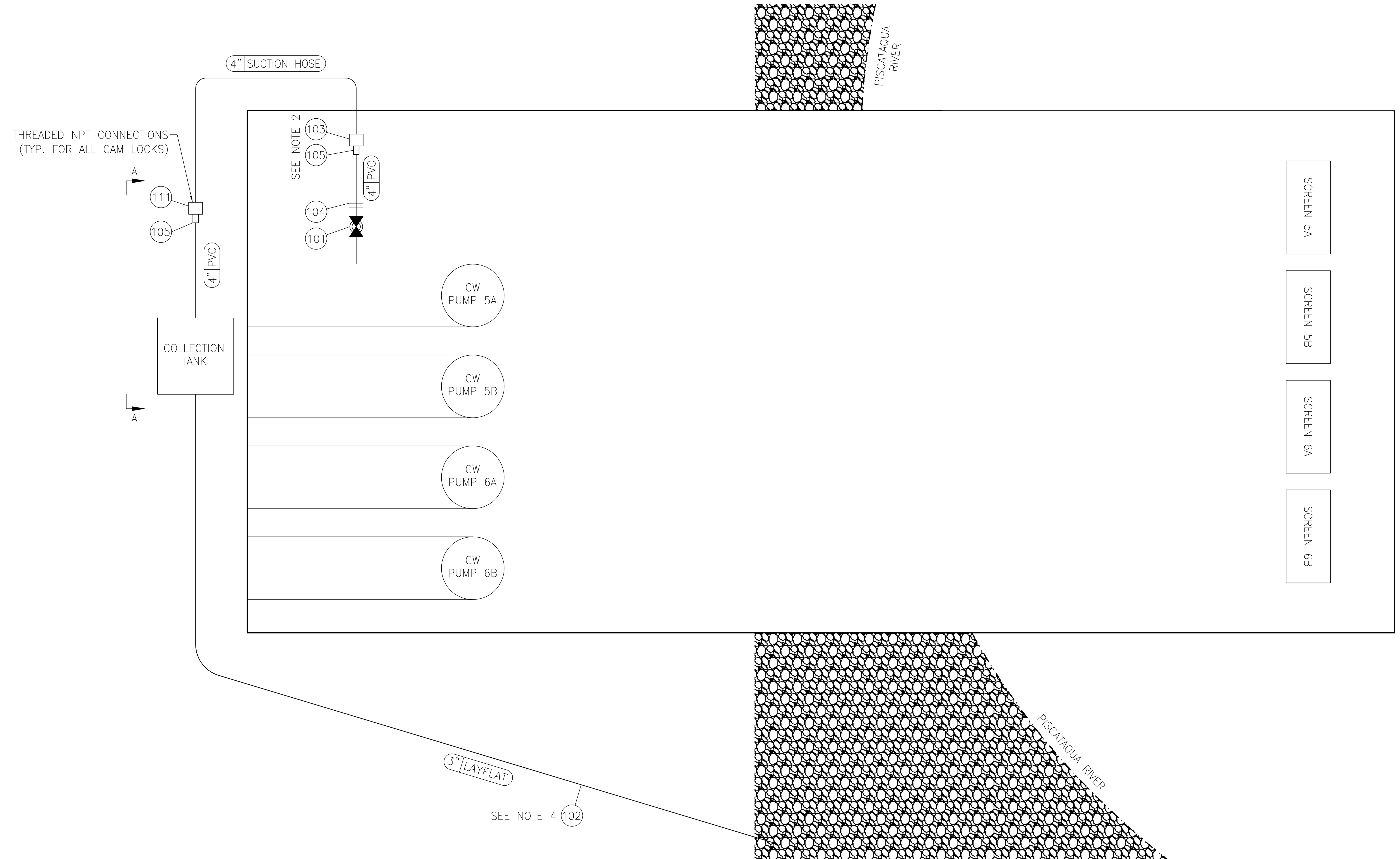
GRANITE SHORE POWER LLC
SCHILLER STATION

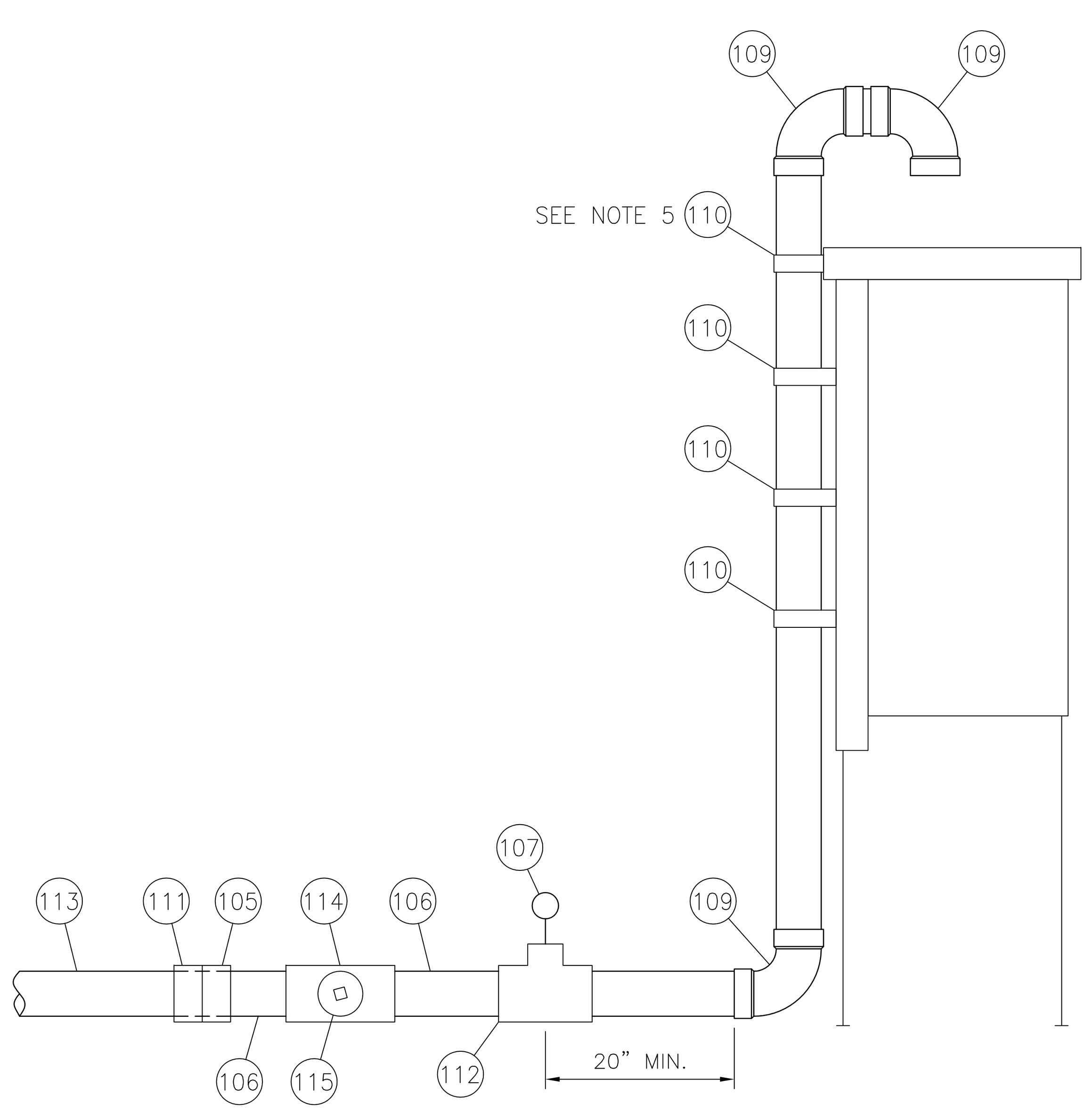
IN-RIVER TESTING
TEST SAMPLING LAYOUT

SIZE	DWG NO.	REV
D	GSPL-00001-M-002	0

SCALE NONE | SHEET 2 of 2



PLAN VIEW



SECTION A–A

BILL OF MATERIALS			
NO.	QTY.	DESCRIPTION	SPEC. NO.
101	1	4" BRASS BALL VALVE	–
102	–	3" DISCHARGE HOSE	002
103	1	4" ANODIZED ALUMINUM CAM–LOCK PLUG x NPT MALE	–
104	1	4" NPT GALVANIZED STEEL THREADED FLANGE	–
105	2	4" PVC ADAPTOR, SOCKET FEMALE x NPT FEMALE	–
106	–	4" PVC PIPE	002
107	1	4" FLOW METER	005
108	1	1/16" THICK 3" ANSI CLASS 150 GASKET	–
109	3	4" PVC 90–DEGREE LONG ELBOW CONNECTOR	–
110	4	PLASTIC ROUTING CLAMP FOR 3" PVC PIPE	–
111	1	4" ANODIZED ALUMINUM CAM–LOCK SOCKET x NPT MALE	–
112	1	GF SIGNET 4" PVC SADDLE INSTALLATION FITTING	–
113	–	4" SUCTION HOSE	002
114	1	4" x 4" x 4" PVC PIPE TEE x NPT FEMALE	–
115	1	4" PVC NPT MALE PLUG	–

NOTES:

1. UNLESS OTHERWISE NOTED, ALL PVC PIPING AND FITTINGS ARE CONNECTED USING FIELD–TO–FIT CUT PIECES OF THE NOMINAL PVC PIPE SIZE AND PVC ADHESIVE.
2. BOM ITEMS 101 AND 104 EXISTING.
3. FIELD TO FIT ALL ELECTRICAL CONNECTIONS.
4. FIELD ROUTE DISCHARGE HOSE.
5. STARTING AT TOP OF TANK, INSTALL CLAMP EVERY 24" DOWN SIDE OF TANK.

REV	DESCRIPTION	DRN	CHK	REV	APP	DATE
0	INITIAL ISSUE					

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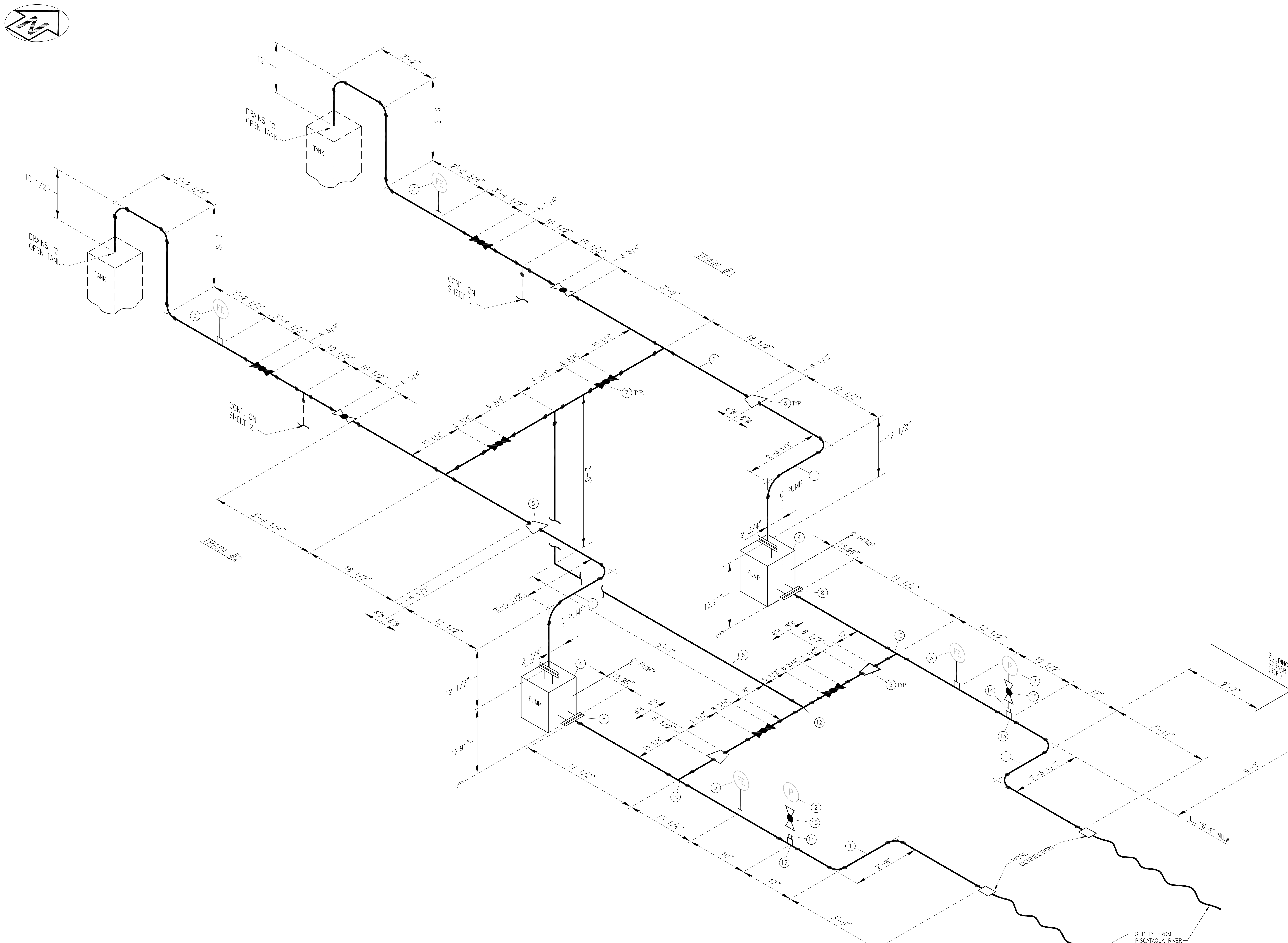
GRANITE SHORE POWER LLC
SCHILLER STATION

IN-RIVER TESTING
CONTROL SAMPLING LAYOUT

SIZE	DWG NO.	REV
D	GSPL-00001-M-003	0

SCALE NONE | SHEET 1 of 1



SUPPLY ⟶ PUMP ⟶ TANK

BILL OF MATERIAL		
ITEM NO.	QTY.	DESCRIPTION
1	—	6" SCH. 80 PVC PIPE
2	2	PRESSURE TRANSMITTER, ROSEMOUNT M/N 3051S2CG3A2F12A1A
3	5	FLOW METER, GF SIGNET MAGMETER, M/N 2551
4	2	BARMESA TRASH PUMP, M/N SH6-U
5	4	6" x 4" SCH. 80 PVC REDUCER
6	—	4" SCH. 80 PVC PIPE
7	8	4" PVC BALL VALVE
8	2	6" PVC FLANGE
9	8	6" SCH. 80 PVC 90° ELBOW, SOCKET
10	2	6" SCH. 80 PVC TEE, SOCKET
11	8	4" SCH. 80 PVC 90° ELBOW, SOCKET
12	6	4" SCH. 80 PVC TEE, SOCKET
13	2	6" x 6" x 1" SCH. 80 PVC REDUCING TEE, SOCKET
14	2	1/2" REDUCING INSERT
15	2	1/2" BALL VALVE, FIG. 5592AB

NOTES:

REFERENCES:

REV	DESCRIPTION	DRN	CHK	REV	APP	DATE
0	INITIAL ISSUE					

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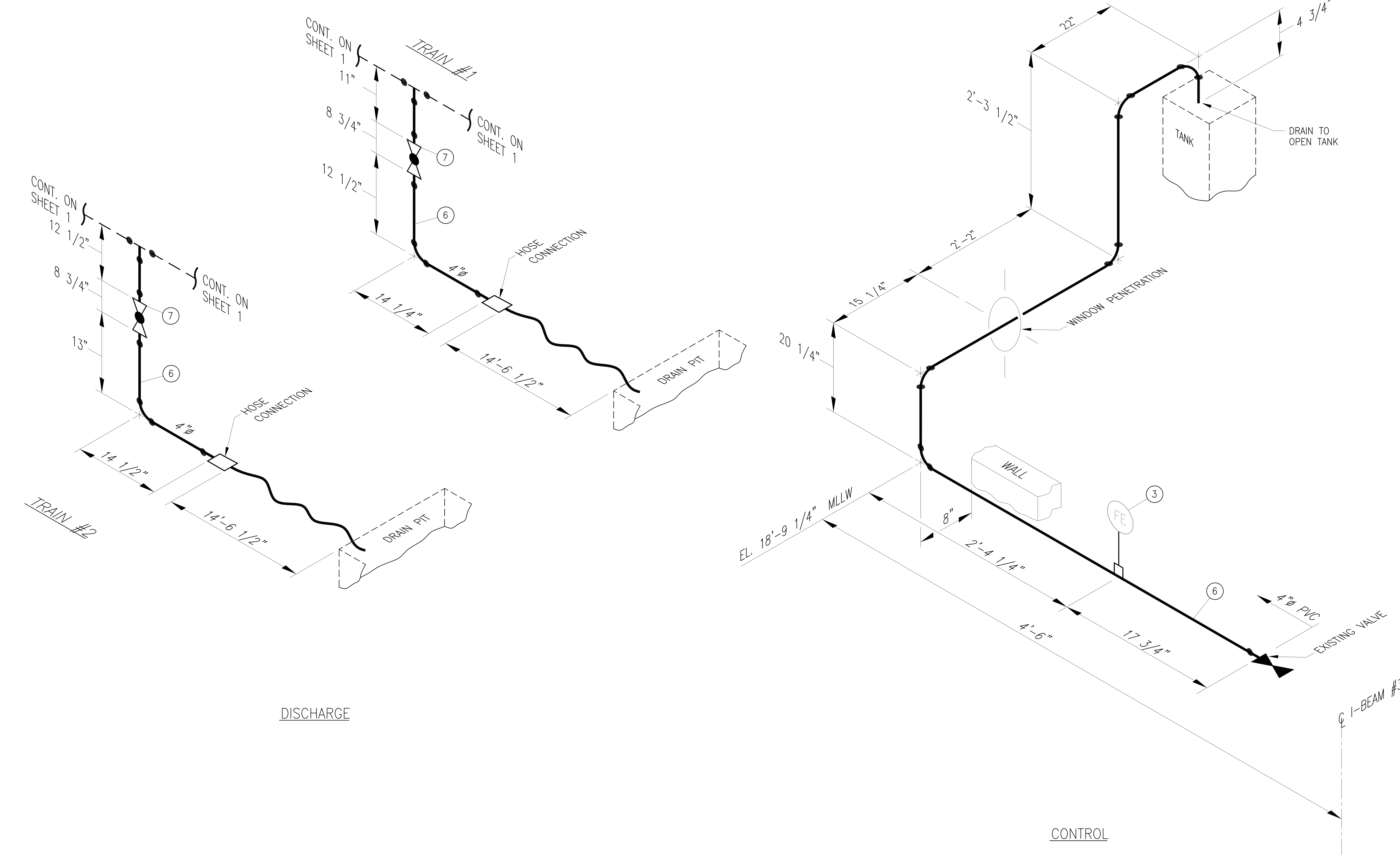
GRANITE SHORE POWER LLC
SCHILLER STATION

IN-RIVER TESTING
AS-BUILT ISOMETRICS

SIZE	DWG NO.	REV
D	GSPL-00001-M-004	0
SCALE: NONE		SHEET 1 of 2



REV	DESCRIPTION	DRN	CHK	REV	APP	DATE
0	INITIAL ISSUE					

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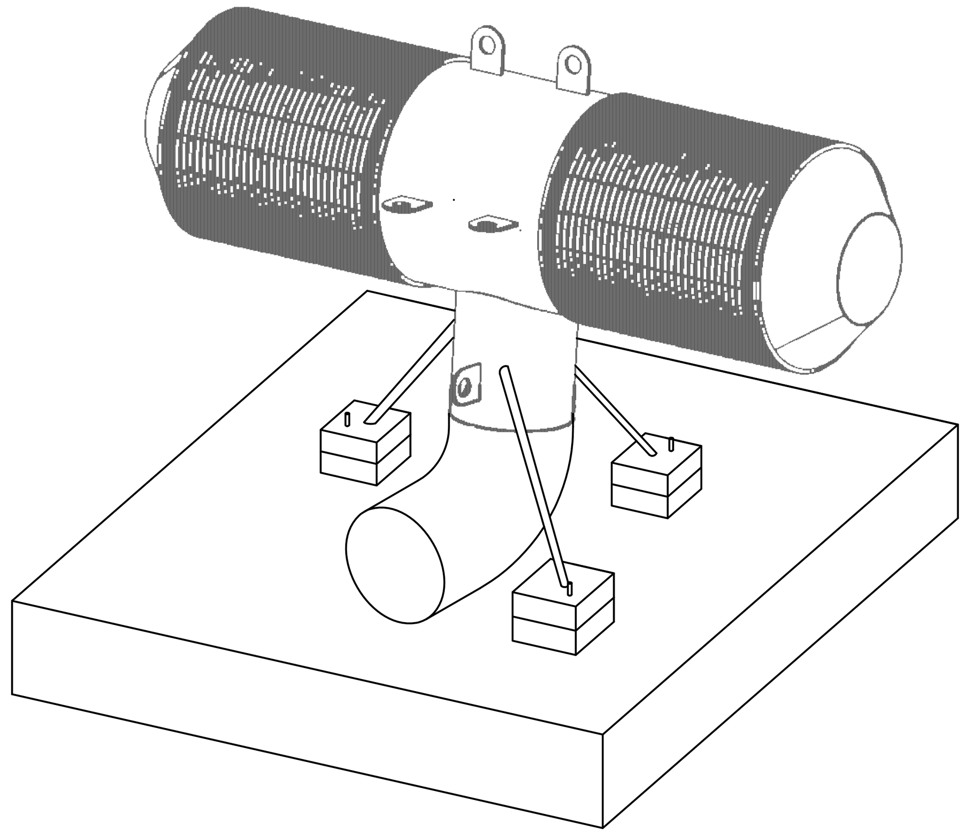
GRANITE SHORE POWER LLC
SCHILLER STATION

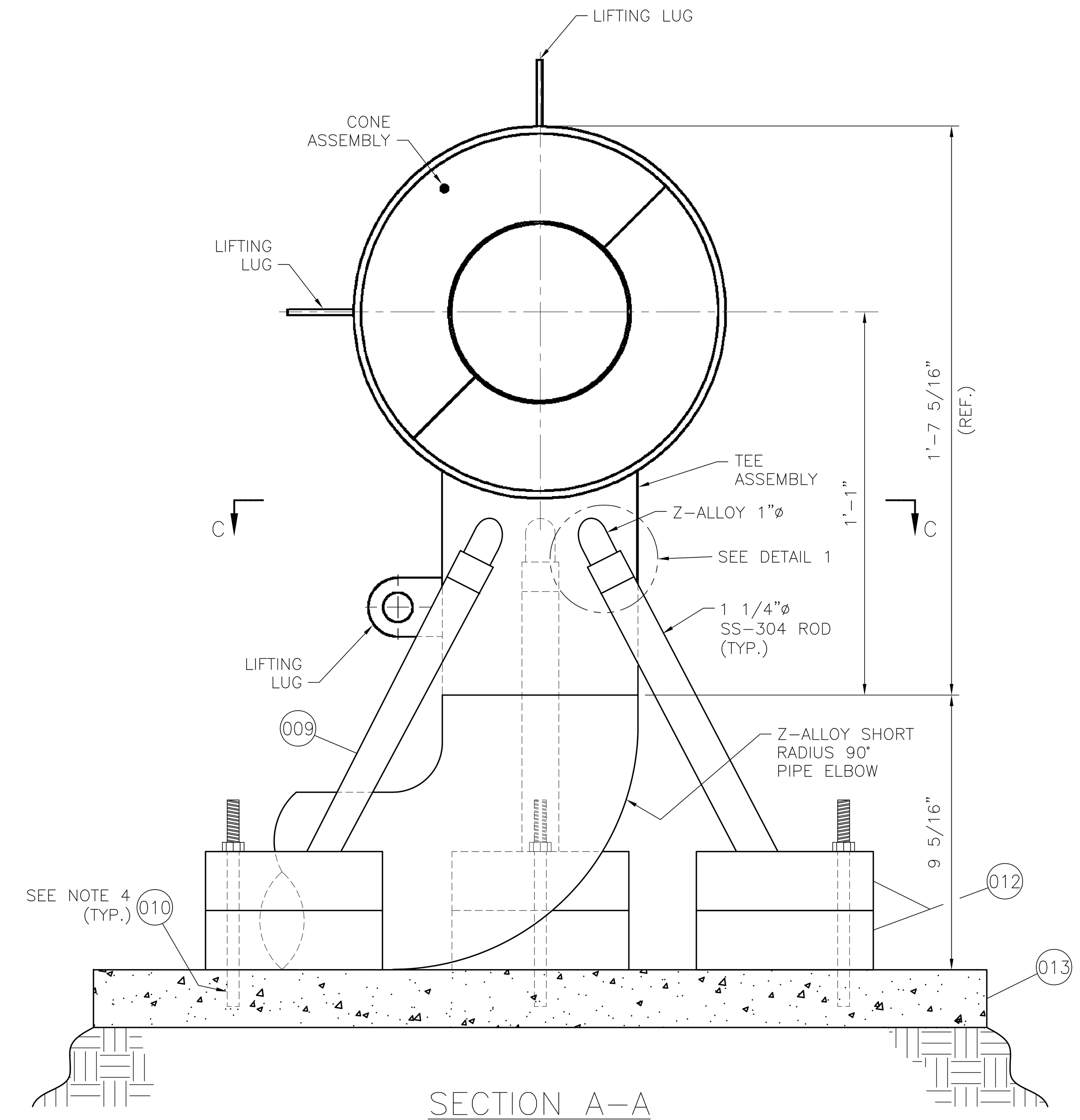
IN-RIVER TESTING
AS-BUILT ISOMETRICS

SIZE	DWG NO.	REV
D	GSPL-00001-M-004	0

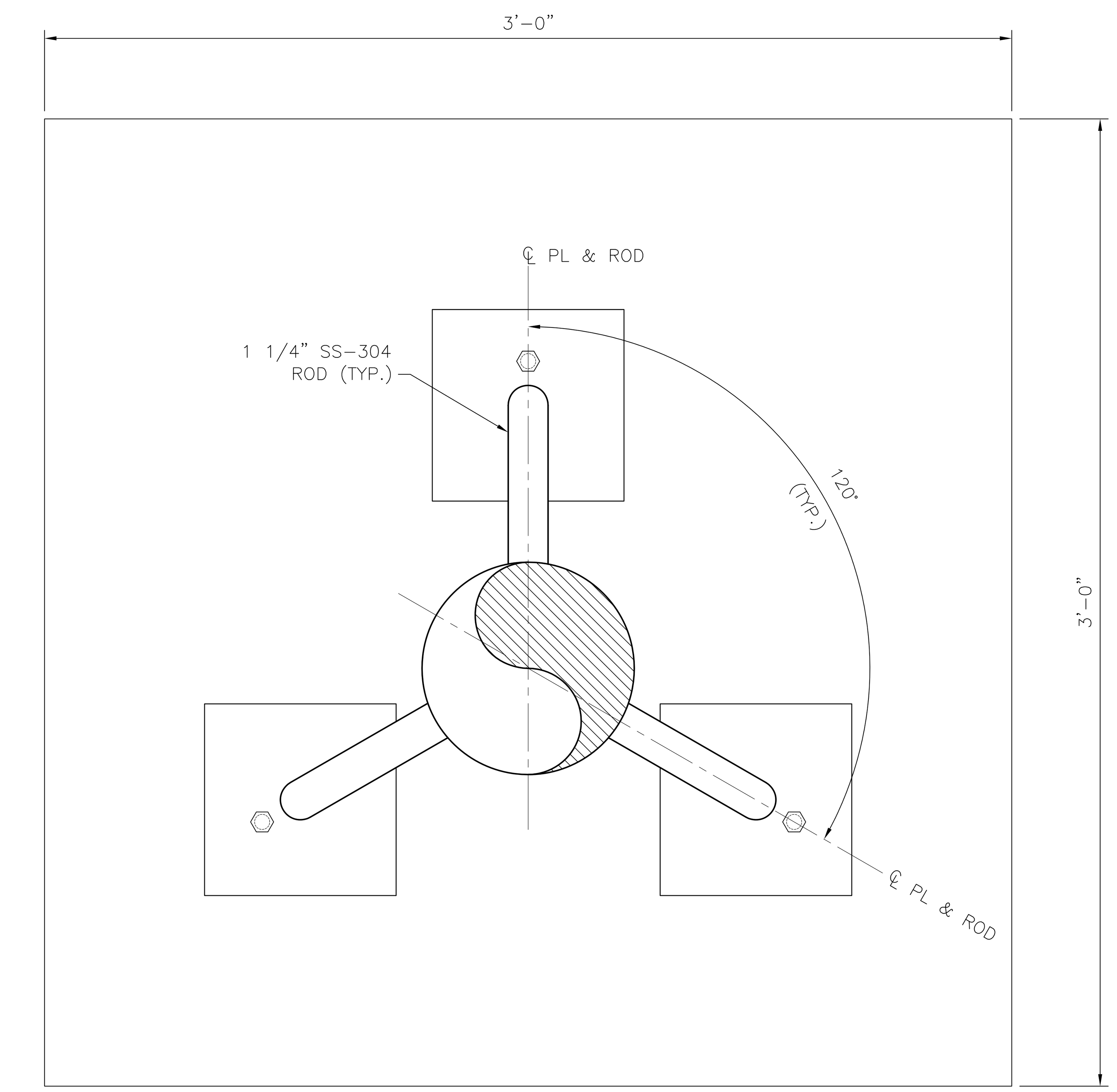
SCALE NONE | SHEET 2 of 2

BILL OF MATERIALS			
NO.	QTY.	DESCRIPTION	SPEC. NO.
001	6	NYLON CAPS, 3" INNER HEIGHT	–
002	3	304 SS COUPLER	–
003	3	A400 BOLT 1/2" x 2.5" LG.	–
004	3	A400 NUT 1/2"	–
005	3	SS BOLT 3/8" x 2.5" LG.	–
006	3	SS NUT 3/8"	–
007	6	VINYL WASHERS 3/8"	–
008	6	PTFE SPACER	–
009	3	SS TRIPOD LEG	–
010	3	ANCHOR BOLT	–
011	–	ANCHOR ADHESIVE	–
012	6	SS PLATE	–
013	1	CONCRETE PAD	007
014	6	VINYL WASHERS 1/2"	–

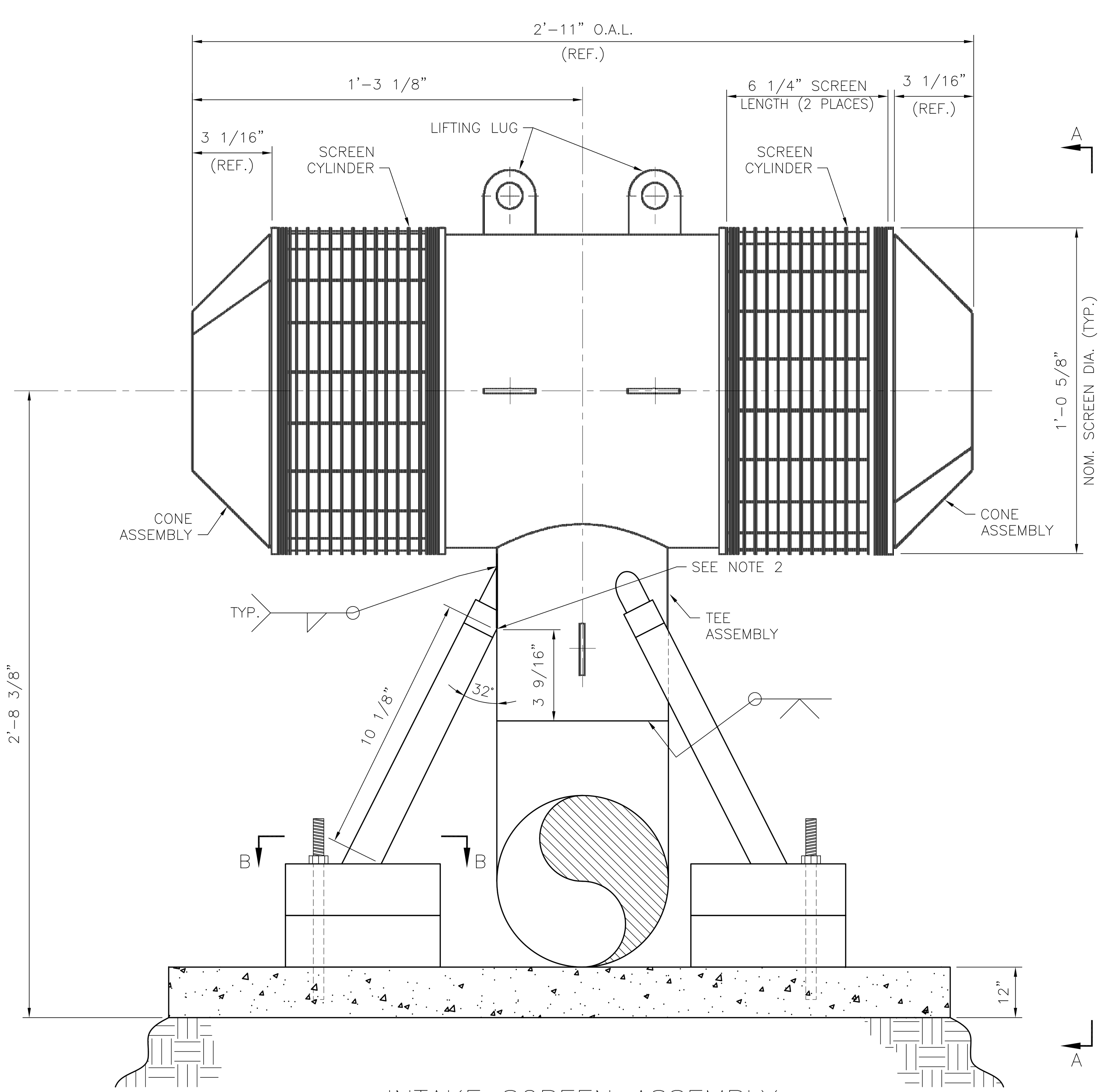




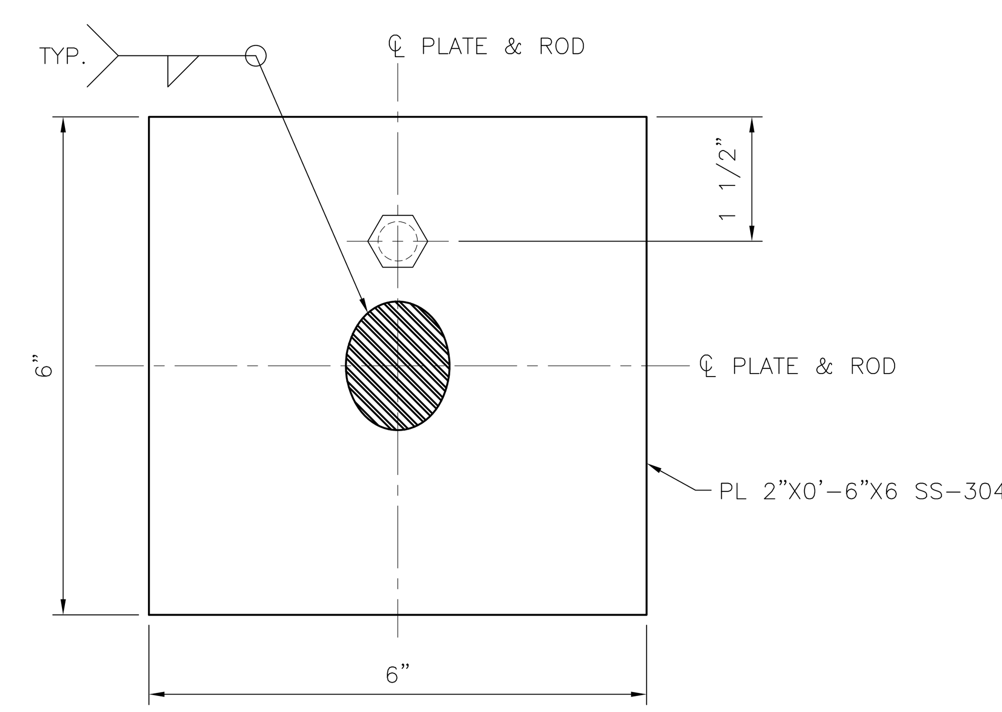
SECTION A–A



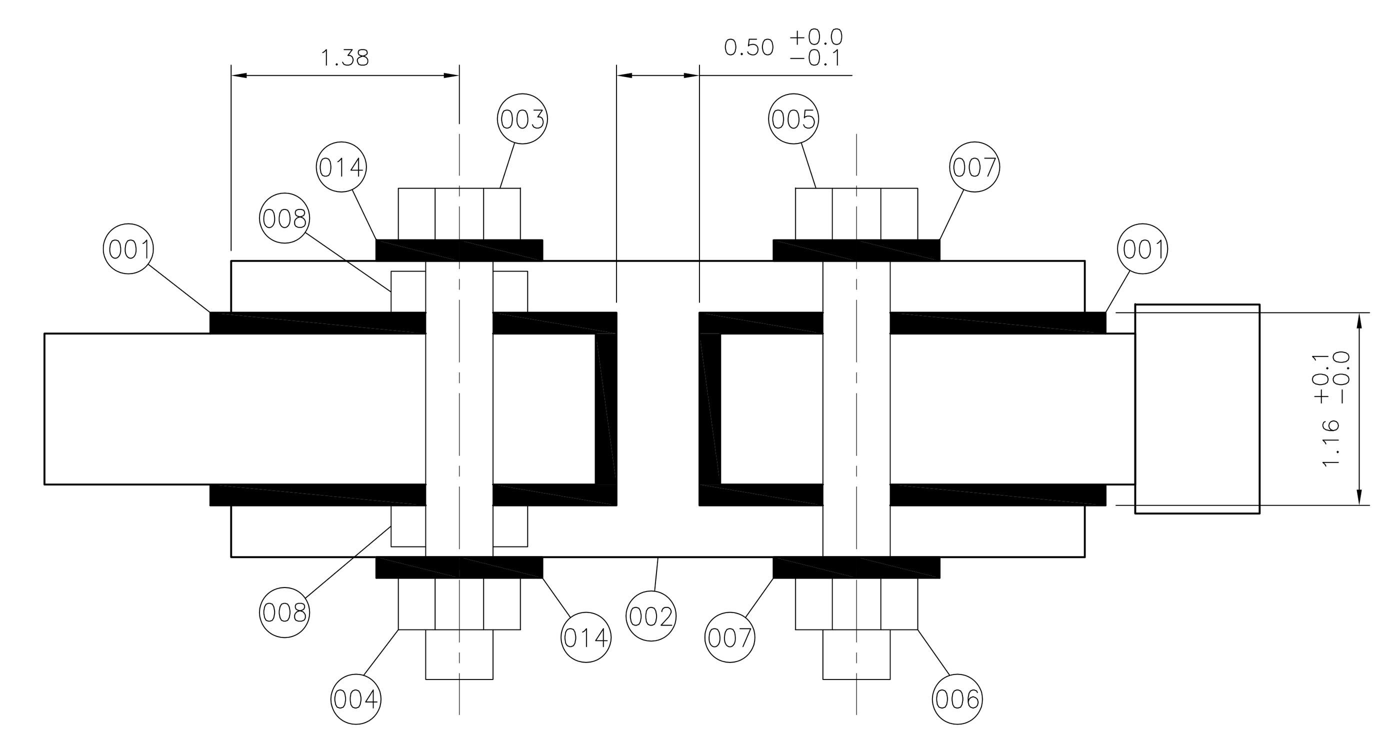
SECTION C–C
LEG MOUNTING ORIENTATION
(SEE NOTE 3)



INTAKE SCREEN ASSEMBLY



SECTION B–B



DETAIL 1

NOTES:

1. ALL WELDS SHALL COMPLY WITH AWS D1.6–2007.
2. RODS SHALL BE CUT AT AN ANGLE TO WELD TO THE PIPE ASSEMBLY.
3. THE 3 TRIPOD LEGS SHALL BE WELDED AROUND THE PIPE AND SEPARATED BY 120°.
4. ANCHOR BOLT 2.75" EMBEDMENT.

REV	DESCRIPTION	DRN	CHK	REV	APP	DATE
0	INITIAL ISSUE					

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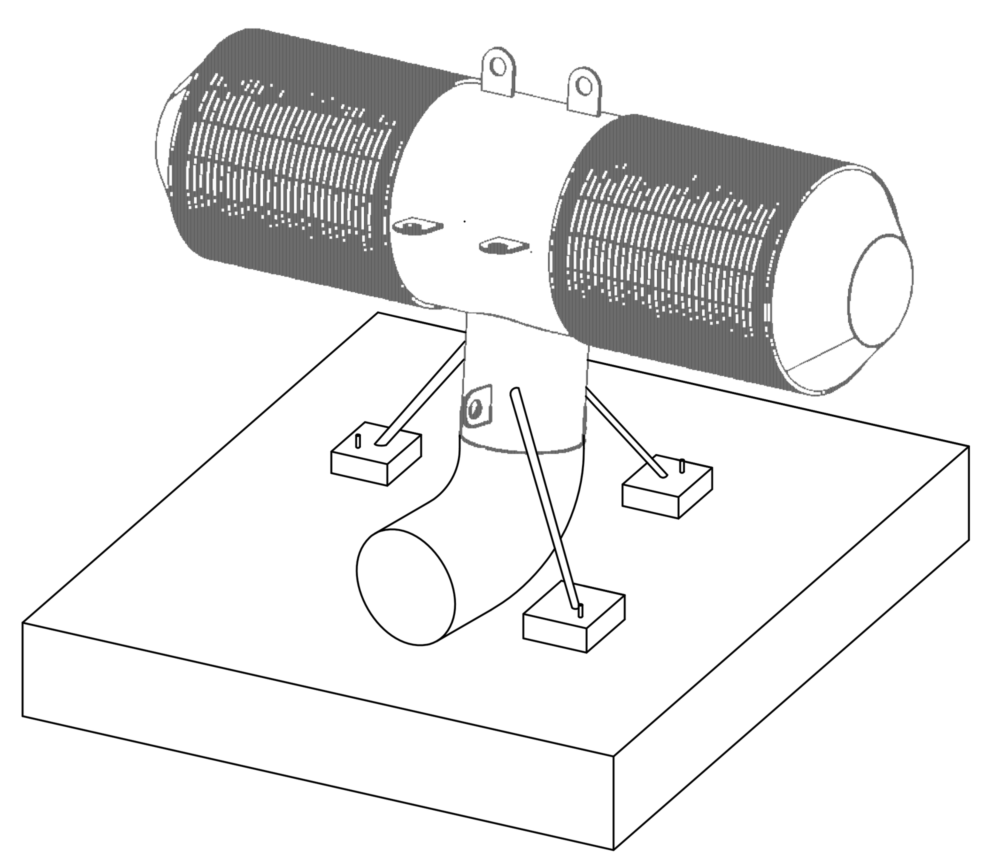
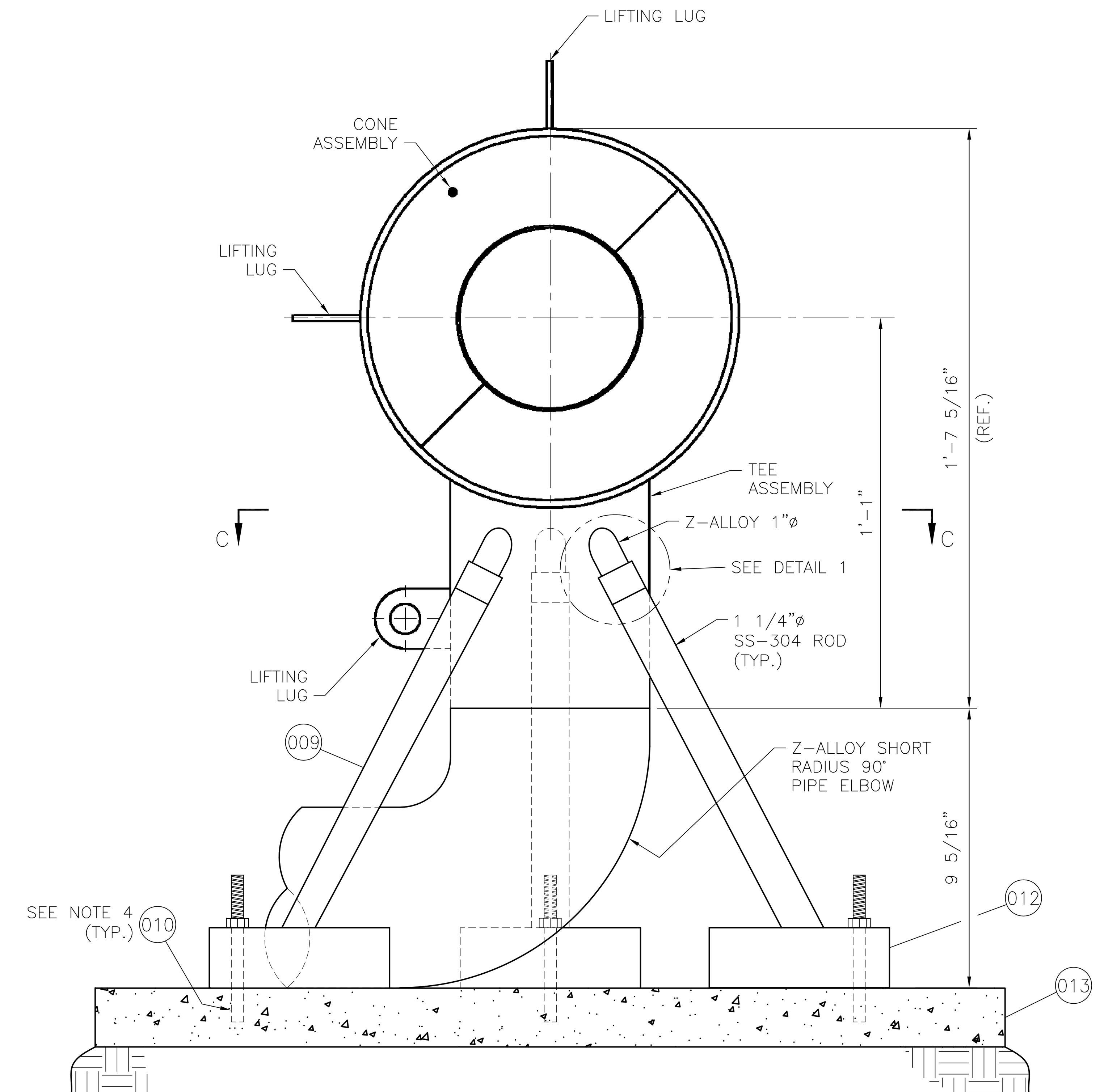
SCHILLER STATION

3.0MM WEDGEWIRE SCREEN AND TRIPOD SUPPORT

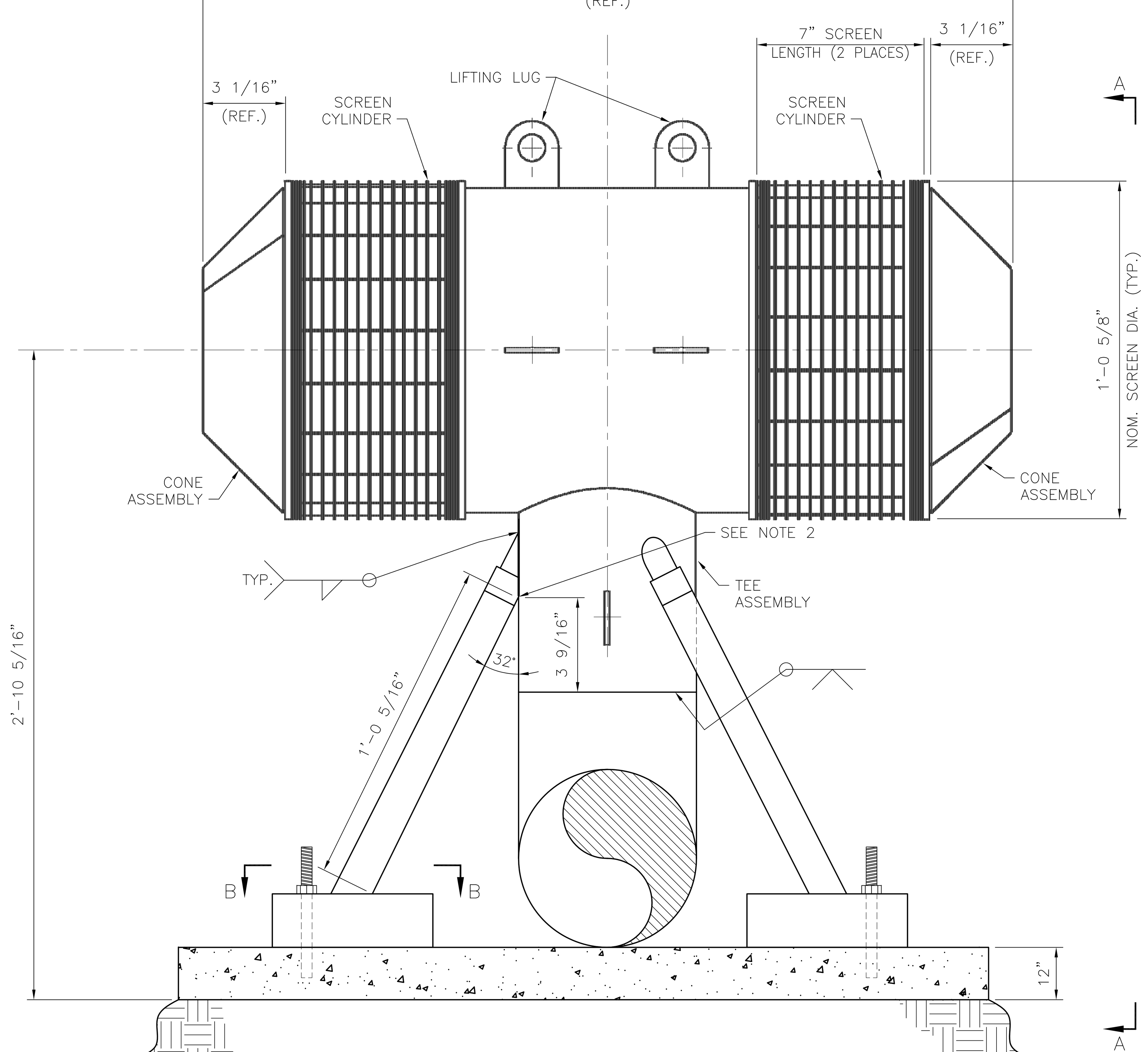
SIZE D | DWG NO. GSPL-00001-SK-002 | REV 0
SCALE NONE | SHEET 1 of 1

BILL OF MATERIALS			
NO.	QTY.	DESCRIPTION	SPEC. NO.
001	6	NYLON CAPS, 3" INNER HEIGHT	–
002	3	304 SS COUPLER	–
003	3	A400 BOLT 1/2" x 2.5" LG.	–
004	3	A400 NUT 1/2"	–
005	3	SS BOLT 3/8" x 2.5" LG.	–
006	3	SS NUT 3/8"	–
007	6	VINYL WASHERS 3/8"	–
008	6	PTFE SPACER	–
009	3	SS TRIPOD LEG	–
010	3	ANCHOR BOLT	–
011	–	ANCHOR ADHESIVE	–
012	3	SS PLATE	–
013	1	CONCRETE PAD	007
014	6	VINYL WASHERS 1/2"	–

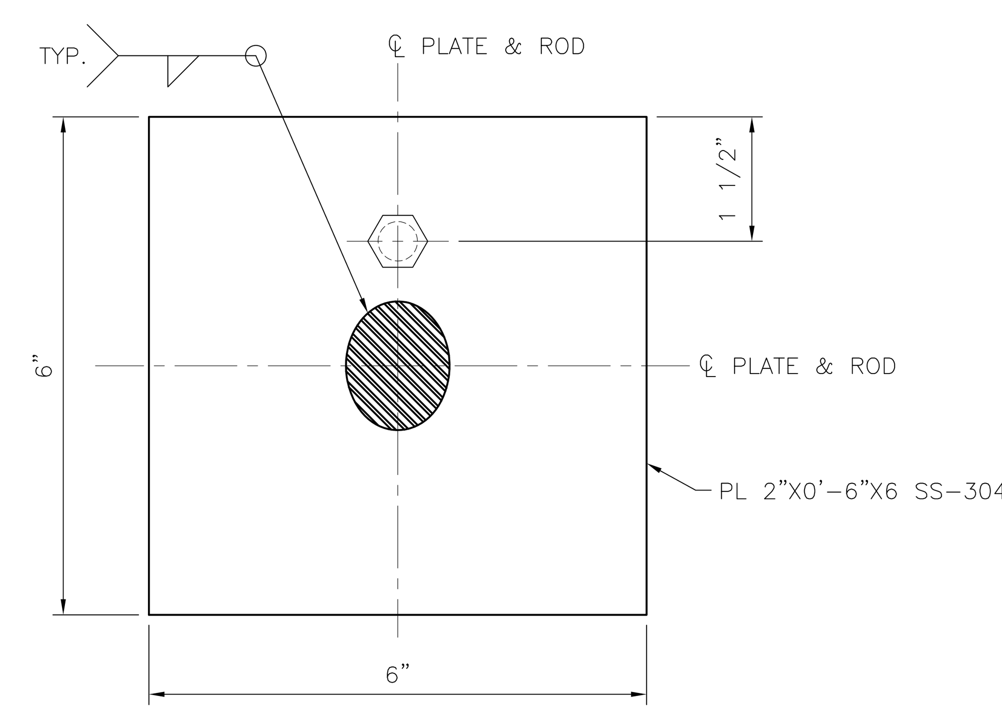




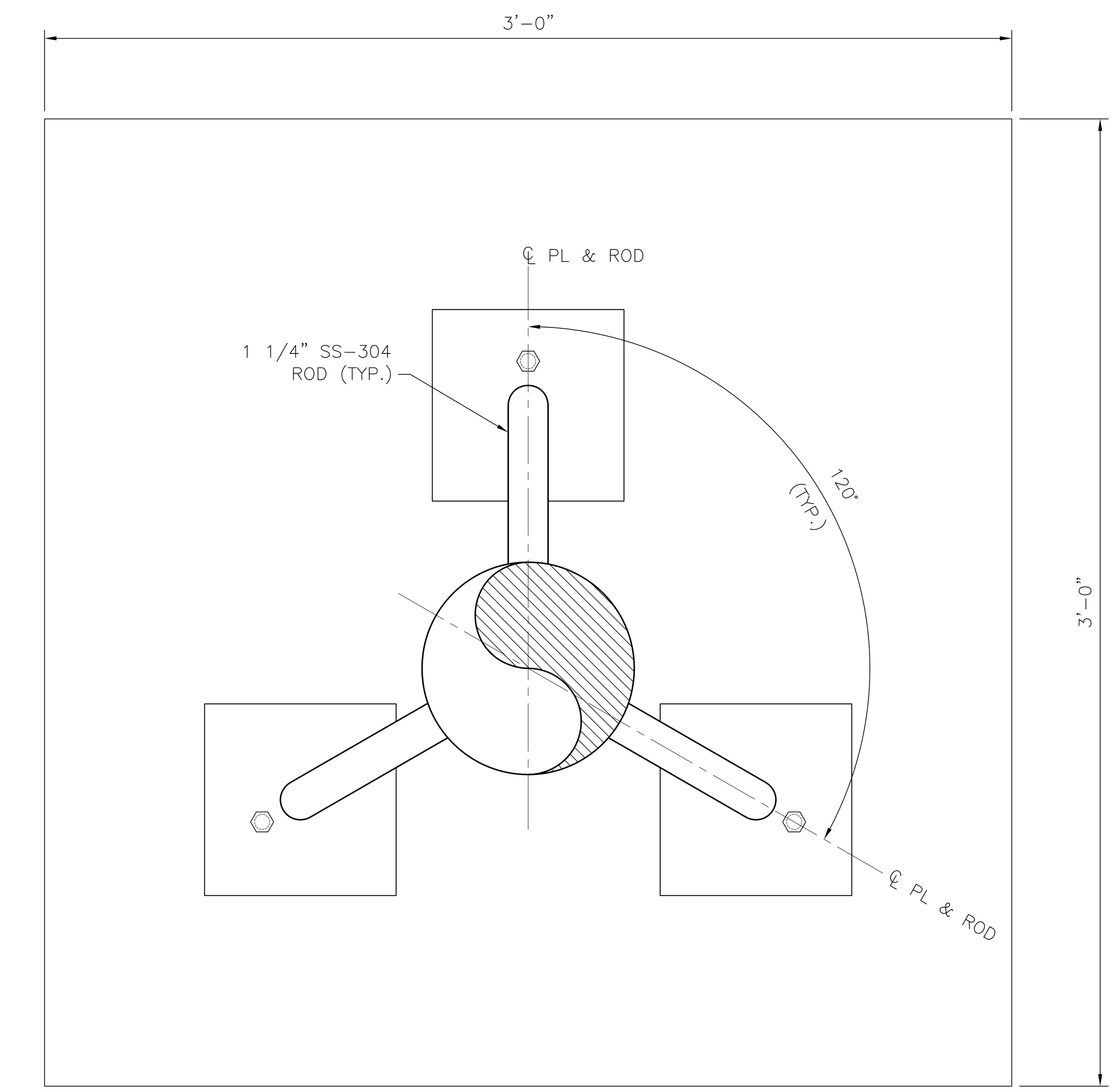
SECTION A–A



INTAKE SCREEN ASSEMBLY



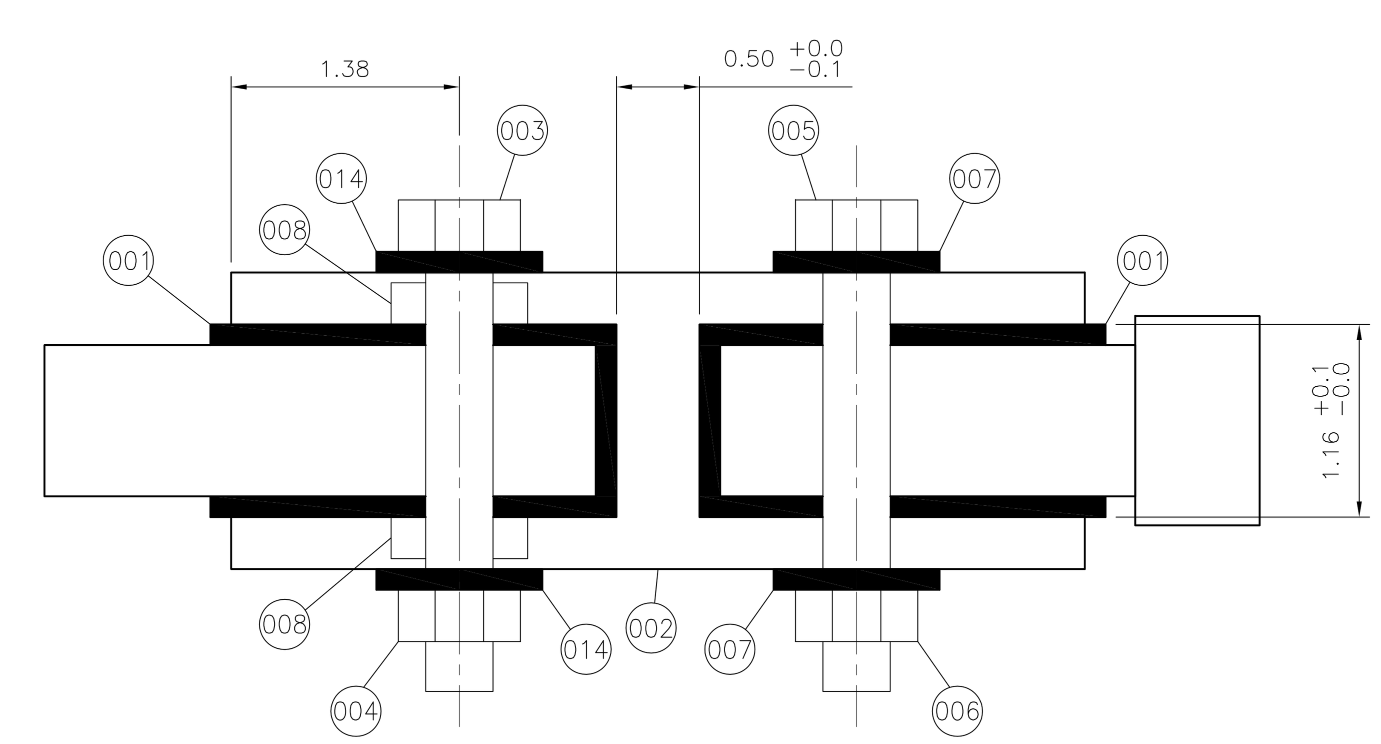
SECTION B–B



SECTION C–C
LEG MOUNTING ORIENTATION
(SEE NOTE 3)

NOTES:

1. ALL WELDS SHALL COMPLY WITH AWS D1.6–2007.
2. RODS SHALL BE CUT AT AN ANGLE TO WELD TO THE PIPE ASSEMBLY.
3. THE 3 TRIPOD LEGS SHALL BE WELDED AROUND THE PIPE AND SEPARATED BY 120°.
4. ANCHOR BOLT 2.75" EMBEDMENT.



DETAIL 1

REV	DESCRIPTION	DRN	CHK	REV	APP	DATE
0	INITIAL ISSUE					

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KENNESAW, GA 30144

GRANITE SHORE POWER LLC
SCHILLER STATION

0.8MM WEDGEWIRE SCREEN AND TRIPOD SUPPORT

SIZE D | DWG NO. GSPL-00001-SK-001 | REV 0
SCALE NONE | SHEET 1 of 1

For: GSP Schiller Plant	**Project:** *GSP Schiller Plant- Wedge Wire Pipe Support Design* Revision 0- IFR	Prepared by : Mehul Patel Date:08/01/18 Checker: Date:_______

Load Inputs for GSP Schiller Plant Wedge Wire Support

River Current Load

Water Pressure: $F_{water} = A\rho v^2$

Where: $v := 16 \cdot \frac{ft}{sec}$ *v = Max Current Velocity at Piscataqua River near the GSP Schiller Nuclear Plant. x F.S of 2*

$q_{allowable} := 1000 \frac{lbf}{ft^2}$ *Assumed Allowable bearing on water-bed*

$\gamma_{steel} := 492.5 \frac{lb}{ft^3}$ *Density of SS 304*

$\gamma_{water} := 62.4 \frac{lb}{ft^3}$ *Density of water*

$\gamma_{concrete} := 150 \frac{lbf}{ft^3}$ *Density of Concrete*

$C_d := 1.2$ *Drag Coefficient for Round Members*

$D_{screen} := 1.052ft$ *Diameter of screen*

$D_{outlet} := .553ft$ *Diameter of Outlet Connection*

$L_{outlet} := .5ft$ *Length of Outlet Connection*

$W_{screen} := 160lbf$ *Weight of Screen*

$W_{outlet} := 80lbf$ *Weight of Outlet*

$w_{pad} := 36in$ Width of concrete pad

$l_{pad} := 36in$ Length of concrete pad

$t_{pad} := 6in$ Thickness of concrete pad

$W_{pad} := \gamma_{concrete} \cdot (w_{pad} \cdot l_{pad} \cdot t_{pad}) = 675 \cdot lbf$ Weight of concrete pad

$l_{plate} := 6in$ *Design Length of plate*

$w_{plate} := 6in$ *Design Width of plate*

$t_{plate} := 2in$ *Design Thickness of plate*

$W_{plate} := (l_{plate} \cdot w_{plate} \cdot t_{plate}) \cdot \gamma_{steel} = 20.521 \cdot lb$ *Weight of (1) plate*

For: GSP Schiller Plant	**Project:** GSP Schiller Plant- Wedge Wire Pipe Support Design Revision 0- IFR	Prepared by : Mehul Patel Date:08/01/18 Checker: Date:_______

$W_{tplate} := W_{plate} \cdot 3 = 61.562 \cdot lb$ *Weight of (3) plate*

$W_{tplate} > W_{steel}$ OK

$A_{screen} := \pi \cdot \left(\frac{D_{screen}}{2}\right)^2 = 0.869 \cdot ft^2$ *Wedge Wire Screens Surface Area for Water force*

$A_{outlet} := D_{outlet} \cdot L_{outlet} = 0.277 \cdot ft^2$ *Outlet Connection Surface Area for Water force*

$F_{dynscreen} := \frac{v^2 \cdot \gamma_{water} \cdot (A_{screen}) \cdot C_d}{2} = 258.935 \cdot lbf$ *Dynamic Force of water on Wedge Wire Screens*

$F_{dynoutlet} := \frac{v^2 \cdot \gamma_{water} \cdot (A_{outlet}) \cdot C_d}{2} = 82.369 \cdot lbf$ *Dynamic Force of water on Outlet Connection*

$F_{dynsteel} := 1.5 \cdot F_{dynoutlet} = 123.554 \cdot lbf$ *Assumed Dynamic Force of water on Steel Support*

$F_{dyntotal} := F_{dynscreen} + F_{dynoutlet} + F_{dynsteel} = 464.859 \cdot lbf$

$W_{steel} := 60lbf$ *Estimated weight of Support*

$L_{support} := 1.37121 ft$ *Assumed length of Support*

$L_{marmscreen} := 28.31 in$ *Wedge Wire Screen moment arm*

$L_{marmoutlet} := 21.48 in$ *Outlet Connection moment arm*

$L_{marmsteel} := 16.48 in$ *Steel rods moment arm*

$W_{total} := (W_{screen} + W_{outlet} + W_{steel} + W_{pad}) = 975 \cdot lbf$

$F_{bs} := \frac{\gamma_{steel} - \gamma_{water}}{\gamma_{steel}} = 0.873$ *Buoyant factor for steel*

$F_{bc} := \frac{150 \frac{lb}{ft^3} - \gamma_{water}}{150 \frac{lb}{ft^3}} = 0.584$ *Buoyant factor for concrete*

For: GSP Schiller Plant	**Project:** GSP Schiller Plant- Wedge Wire Pipe Support Design Revision 0- IFR	Prepared by : Mehul Patel Date:08/01/18 Checker: Date:_______

$W_{bouyant} := (W_{screen} \cdot F_{bs} + W_{outlet} \cdot F_{bs} + W_{steel} \cdot F_{bs} + W_{pad} \cdot F_{bc}) = 656.19 \cdot lbf$ *Total submerged weight*

Moment applied at the bottom of the concrete pad

$$M_o := (F_{dynscreen} \cdot L_{marmscreen} + F_{dynoutlet} \cdot L_{marmoutlet} + F_{dynsteel} \cdot L_{marmsteel})$$

$$M_o = 927.993 \cdot ft \cdot lbf$$

$$M_r := (W_{bouyant}) \cdot \frac{l_{pad}}{2} = 984.285 \cdot lbf \cdot ft$$

$$FOS := \frac{M_r}{M_o} = 1.061 \qquad 1.061 > 1 \qquad OK$$

$$q_{max} := \frac{W_{bouyant}}{l_{pad} \cdot w_{pad}} + \frac{M_o \cdot \frac{l_{pad}}{2}}{\left(\frac{l_{pad} \cdot w_{pad}^3}{12}\right)} = 279.131 \cdot \frac{lbf}{ft^2}$$ Max bearing on waterbed with Pressure and Moment

$$\frac{q_{allowable}}{q_{max}} = 3.583 \qquad 3.583 > 1 \qquad OK$$

Steel Rod Check

$F_b := 30ksi$ *Yield Strength of Stainless Steel*

$\phi := .9$ *Strength factor*

$D := 1.25in$ *Diameter of steel rod*

$r := \frac{D}{2} = 0.625 \cdot in$ *Radius of steel rod*

$A_{rod} := \pi r^2 = 1.227 \cdot in^2$ *Area of steel rod*

$S_{rod} := \pi \frac{r^3}{4} = 0.192 \cdot in^3$ *Section Modulus of steel rod*

$f_b := \frac{M_o}{3S_{rod}} = 1.936 \times 10^4 \cdot \frac{lbf}{in^2}$ *Applied Stress on steel rod*

$\frac{F_b}{f_b} = 1.55 \qquad 1.55 > 1.5$ *Factor of Safety*

For: GSP Schiller Plant	**Project:** *GSP Schiller Plant- Wedge Wire Pipe Support Design*	Prepared by : Mehul Patel Date:08/01/18 Checker: Date:_______
	Revision 0- IFR	

Reinforcement Design

Vertical load

$V_u := W_{bouyant} = 0.656 \cdot kip$

Bending moment

$M_u := M_o = 0.928 \cdot ft \cdot kip$

Lateral load

$H_u := F_{dyntotal} = 0.465 \cdot kip$

$f_c := 3ksi$ Concrete Compressive Strength

$\phi_c := .9$ Strength factor

$f_y := 60ksi$ Yield Strength of rebar

$b_w := 12in$ Design width

$d := 3in$ Depth to rebar

$M_u = \phi \cdot M_n$

$M_n := \dfrac{M_u}{\phi_c} = 1.031 \cdot kip \cdot ft$

$M_n = A_s \cdot f_y \cdot (d - y)$

$a = \dfrac{A_s \cdot f_y}{.85 \cdot f_c \cdot b_w}$ $\qquad A_s = \dfrac{M_n}{f_y \cdot (d - y)}$ $\qquad y = \dfrac{a}{2}$

$a := .2 \cdot d = 0.6 \cdot in$

$$A_{s1} := \frac{M_n}{f_y \cdot \left(d - \frac{a}{2}\right)} = 0.076 \cdot in^2$$

$$a_1 := \frac{A_{s1} \cdot f_y}{.85 \cdot f_c \cdot b_w} = 0.15 \cdot in \qquad .15in \neq .6in$$

$$A_{s2} := \frac{M_n}{f_y \cdot \left(d - \frac{a_1}{2}\right)} = 0.07 \cdot in^2$$

$$a_2 := \frac{A_{s2} \cdot f_y}{.85 \cdot f_c \cdot b_w} = 0.138 \cdot in \qquad .138 = .15$$

$$A_{s3} := \frac{M_n}{f_y \cdot \left(d - \frac{a_2}{2}\right)} = 0.07 \cdot in^2$$

$$a_3 := \frac{A_{s3} \cdot f_y}{.85 \cdot f_c \cdot b_w} = 0.138 \cdot in \qquad .138 = .138$$

For: GSP Schiller Plant	**Project:** GSP Schiller Plant- Wedge Wire Pipe Support Design Revision 0- IFR	Prepared by : Mehul Patel Date:08/01/18 Checker: Date:_______

$A_{sreq} := A_{s3} = 0.07 \cdot in^2$ Min. required Steel per foot is .07 in^2

$$A_{smin} = \frac{3 \cdot \sqrt{f_c} \cdot b_w \cdot d}{f_y} \geq \frac{200 \cdot b_w \cdot d}{f_y}$$

$$A_{smin} := \frac{200 \cdot 12 \cdot 2}{60000} = 0.08$$

$A_s := .11 in^2 \cdot \left(\frac{12}{12}\right) = 0.11 \cdot in^2$ $\quad .11in^2 > .08in^2 \quad$ OK

<u>Use #3 @12" On center each direction</u>

Hilti Anchor Design

$Num_{anchor} := 3$ *number of anchor bolts*

$d_{anchor} := .5 \cdot in$ *anchor rod diameter*

$Diameter_{boltcircle.anchor} := 22 \cdot in$ *anchor bolt spacing (diagonal)*

Ft.anchor calculation

$M_{anchor} := M_o = 0.928 \cdot kip \cdot ft$

$$A_{net.anchor} := \frac{\pi}{4} \cdot \left(d_{anchor} - \frac{0.9743}{\frac{4}{in}}\right)^2 = 0.05 \cdot in^2$$ <u>*LTS Eqn 5-23*</u>

$$I_{anchor} := \frac{Diameter_{boltcircle.anchor}^{\ 2}}{8} \cdot A_{net.anchor} \cdot Num_{anchor} = 9.373 \cdot in^4$$

$$S_{anchor} := \frac{I_{anchor}}{\frac{Diameter_{boltcircle.anchor}}{2}} = 0.852 \cdot in^3$$

$$f_{t.anchor} := \frac{M_{anchor}}{S_{anchor}} = 13.069 \cdot ksi$$

$$F_{t.anchor.calc} := f_{t.anchor} \cdot A_{net.anchor} = 0.675 \cdot kip$$

For: GSP Schiller Plant	**Project:** GSP Schiller Plant- Wedge Wire Pipe Support Design Revision 0- IFR	Prepared by : Mehul Patel Date:08/01/18 Checker: Date:_______

$T_{1bolt.2} := F_{t.anchor.calc} = 0.675 \cdot kip$

$V_{1bolt.2} := \dfrac{F_{dyntotal}}{4} = 0.116 \cdot kip$

Use Hilti HIT 100 anchor system using HIT-HY 100 Adhesive.

Use 1/2 in diameter ASTM A307 Grade A threaded rod. Nominal bit size is 9/16 in.

Use 2.75" embedment

Conservatively use uncracked concrete with fc=3000psi.

Technical specifications found in the HIT-HY 100 Adhesive Anchoring System manual.

Pullout check

$F_{pullout} := 3895 lbf$ Allowable pullout force

$T_{1bolt.2} = 674.904 \cdot lbf$ Max tension force

Since max tension in a single bolt is less than the allowable pullout force the adhesive will remain bonded to the hole.

Unity check for adhesive

$\phi N_{dry} := 3895 lbf$

$\phi V_{dry} := 8395 lbf$

$\alpha := .85$ Factor to convert from dry concrete conditions to water saturated concrete conditions (Note 6, table 39, page 26 of 69 in above manual)

$\phi N_w := \alpha \cdot \phi N_{dry} = 3.311 \times 10^3 \cdot lbf$

$\phi V_w := \alpha \cdot \phi V_{dry} = 7.136 \times 10^3 \cdot lbf$

$$\left[\left(\frac{T_{1bolt.2}}{\phi N_w}\right)^2 + \left(\frac{V_{1bolt.2}}{\phi V_w}\right)^2\right]^{\frac{1}{2}} = 0.205 \qquad .205 < 1 \qquad \text{OK}$$

Unity check for threaded rod

$\phi N_{sa} := 6690 lbf$

$\phi V_{sa} := 3705 lbf$

$$\left[\left(\frac{T_{1bolt.2}}{\phi N_{sa}}\right)^2 + \left(\frac{V_{1bolt.2}}{\phi V_{sa}}\right)^2\right]^{\frac{1}{2}} = 0.106 \qquad .106 < 1 \qquad \text{OK}$$

A.0 ADDENDUM A: CHANGE OF EQUIPMENT

A.1 DESCRIPTION OF ADDENDUM

This addendum was generated following a change of equipment for securing and anchoring the intake hoses. The change resulted in an update to Section 3.2. This addendum details the new equipment that was used for securing and anchoring the intake hoses. Initially, Penetrating Earth Anchors were specified to secure the intake hoses but were found inadequate at Schiller Station due to the exposed ledge surface found at the riverbed of the Piscataqua River. Dor Mor Anchors were used for securing the intake hoses rather than the initially specified Penetrating Earth Anchors.

A.2 SUCTION HOSE DRAG FORCE

In Section 3.2 of the main body, an analysis was done to account for the forces experienced by the intake hoses. The analysis was then used to calculate the anchoring force required to secure the intake hoses from being moved by the sweeping river flow. In order to secure the intake hoses, the anchoring force was required to be greater than the net drag force.

From Section 3.2 of the main body, the calculated drag force exerted on the intake hoses was 3,529 lb_f, which was the force exerted by the sweeping river flow. The major counteracting force exerted on the intake hoses was hose friction of 386.65 lb_f. The net drag force that the hoses experienced was the difference between the drag force of 3,529 lb_f and the hose friction of 386.65 lb_f, a total of 3,142.35 lb_f. In order to overcome this exerted force, anchoring of the hoses was required. Dor Mor Anchors, which replaced the originally specified Penetrating Earth Anchors, were installed to provide the required additional force.

A.3 CHANGE OF EQUIPMENT

Originally, Penetrating Earth Anchors were specified for securing the intake hoses. Penetrating Earth Anchors use bolts to penetrate the riverbed, but due to the riverbed surface being mostly exposed ledge, Penetrating Earth Anchors could not be used to secure the hoses. Dor Mor Anchors were installed as the new equipment for securing the intake hoses.

Dor Mor Anchors provided the multi-directional support needed to prevent the sweeping river flow from moving the hoses. Dor Mor Anchors were installed by connecting sets of two anchors to the lashed intake hoses. Ten sets, a total of 20 anchors, were installed approximately every 15 ft. along the length of the hoses.

Each set of Dor Mor Anchors weighed approximately 600 lb_f and applied an anchoring force of 330 lb_f. Ten sets of anchors applied the total force of 3,300 lb_f, overcoming the required force of 3,142.35 lb_f with a margin of 157.65 lb_f.

Figure A-1: Dor Mor Anchors

B.0 ADDENDUM B: LOSS OF SUCTION PRESSURE

B.1 DESCRIPTION OF ADDENDUM

This addendum was generated following an abnormal operating event that occurred on August 31, 2019 and September 1, 2019. During the event, a fluctuating vacuum gauge reading indicating a loss of suction pressure caused a safety trip, turning off both of the sampling pumps. This led to a backflushing of the screens and a visual dive inspection of the pilot wedgewire screens. This addendum details the findings of the inspection and the actions taken as a result of the loss of suction pressure.

B.2 DESCRIPTION OF INSPECTION

A gauge reading indicating a loss of suction pressure on August 31, 2019 prompted a backflushing of the pilot wedgewire screens. The backflushing procedure rejects intake flow of one screen and pumps it through the other screen, in order to remove foulage blocking the pilot wedgewire screens. Following the backflushing, the sampling pump for the north 0.8 mm wedgewire screen did not successfully restart, due to low suction. In response, a dive inspection was scheduled on September 1, 2019 to inspect the cause of the loss of suction pressure.

Initially, the 0.8 mm wedgewire screen was inspected because it was suspected that debris was covering the screen. The inspection observed the north 0.8 mm screen to be clear of major debris that would have caused high suction loss. Further observation of the north 0.8 mm intake hose discovered a large longitudinal fracture approximately two feet in length along the side of the hose. The fracture occurred at a high stress bend between the surface of the water and the entrance to the screen house. Figure B-1 shows the fracture of the north intake hose.

B.3 RESULTS AND CONCLUSION

The damaged section of the north 0.8 mm screen intake hose was spliced and replaced with a new section of hose of the same specification.

In addition to the north 0.8 mm intake hose repair, inspection of the south 3.0 mm wedgewire screen intake hose revealed oblong deformity in a similar location. Reinforcement was added to the deformed hose with an external wrap. To prevent further damage during operation, the wrap was constructed from a spliced section of hose of the same specification.

Following the inspection and repairs, the north intake pump was successfully restarted, regular operations resumed, and scheduled sample collections were continued. Backflushing and inspections continued on an as-needed basis.

Figure B-1: Fractured North Intake Hose

C.0 ADDENDUM C: FOULING AND DAMAGE

C.1 DESCRIPTION OF ADDENDUM

This addendum was generated following a series of underwater inspections that documented the conditions of the pilot wedgewire screens after seven months of continuous operation. This addendum details the amount of screen fouling and damage observed during the underwater inspections from October 1, 2019. The impacts of the observed conditions were estimated based on the imagery captured during the underwater inspection. Further, the efficiency of the backflushing procedure was determined based on the comparison of imagery captured before, during and following the backflushing of the pilot wedgewire screens.

For clarity, subsections of the pilot wedgewire screens are identified by hemicylinders in reference to the installation configuration. The naming convention of the wedgewire screen subsections used in this Addendum follow the configuration provided in Figure C-1.

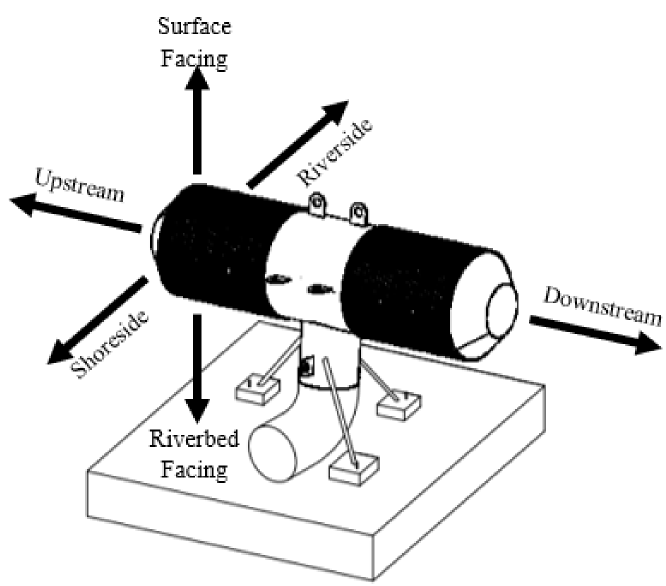


Figure C-1: Pilot Wedgewire Screen Subsection Naming Convention

C.2 DESCRIPTION OF INSPECTIONS

Following a loss of function due to a damaged suction hose, an underwater inspection of the pilot wedgewire screens occurred on September 2, 2019. A notable amount of high hardness (i.e. resistive to mechanical cleaning) fouling was observed along with a moderate amount of biogrowth on the fouling deposits that was clogging the screens. An additional inspection occurred on September 18, 2019 during a scheduled ADCP service dive. An increased amount of fouling was observed during the dive, with an appreciable amount of surface area completely clogged. A backflushing and accompanying inspection occurred on October 1, 2019 in reaction to the amount of observed fouling. Damage to the 0.8 mm wedgewire screen was also identified during this inspection. The information presented in this Addendum was based on the imagery captured during the October 1, 2019 inspection.

C.3 FOULING CALCULATIONS

The fouling observed during the inspections was primarily accumulated along the axial support bars. The pilot wedgewire screens demonstrated different fouling density patterns, suggesting that the fouling deposits were not evenly dispersed on the pilot wedgewire screens. The fouling observed on the pilot wedgewire screens was assumed to be due to mechanical compaction of the fouling deposits against the axial support bars and between the circumferential wire rings. The constant flow compressed the fouling deposits into the wedgewire slot openings. Though the Z-Alloy construction material is anticorrosive and biogrowth resistant, the compacted fouling deposits were believed to have provided a host surface on which biogrowth occurred. It was noted that, while biogrowth occurred where fouling deposits collected, there was a negligible amount of fouling on the risers, flow diverters, and conical end closures.

Based on the imagery captured following the backflushing procedure during the October 1, 2019 inspection, a proportion of clogged surface area was calculated. Each wedgewire screen was constructed with 36 axial support bars, making up 36 distinct divisions around each wedgewire screen or 18 divisions per hemicylindrical subsection. An estimate of clogged surface area was assigned to each division following a graphical evaluation of the inspection imagery. The average percentage of clogged surface area was then determined using an unweighted arithmetic mean. The estimated averages are provided in Tables C-1 and C-2.

Table C-1: 3.0 mm Slot Width Wedgewire Screen Fouling Estimation

Subsection	Percentage Clogged	Percentage Clogged per Side	Total Percentage Clogged
Upstream Shoreside	2%	34%	21%
Upstream Riverside	66%		
Downstream Shoreside	10%	8%	
Downstream Riverside	6%		

Table C-2: 0.8 mm Slot Width Wedgewire Screen Fouling Estimation

Subsection	Percentage Clogged	Percentage Clogged per Side	Total Percentage Clogged
Upstream Shoreside	14%	19%	21%
Upstream Riverside	24%		
Downstream Shoreside	14%	22%	
Downstream Riverside	30%		

Fouling on pilot wedgewire screens creates a lower local percent of open area in the region where the fouling deposits are accumulated resulting in a higher local head loss relative to a unit through slot velocity. In a state of static equilibrium, through slot velocities adjust such that head loss across all regions of the pilot wedgewire screen remain equal. Because fluids follow the most available path of least resistance, the resultant increase in through slot velocity was distributed to the regions of each wedgewire screen with less severe fouling. The local through slot velocity located at regions of less severe fouling is greater than the average through slot velocity. It was anticipated that, due to the fouling pattern observed, the flow through the 3.0 mm wedgewire screen is distributed to favor the subsections other than the upstream riverside subsection. It is anticipated that the flow through the 0.8 mm wedgewire screen was distributed relatively evenly. At design conditions, the 3.0 mm screen and 0.8 mm screen average through slot velocities increased from 0.4 ft/sec to 0.5 ft/sec. The head losses associated with the pilot wedgewire screens remained relatively low and were not perceptible by the vacuum pressure gauge instrumentation.

The imagery from the October 1, 2019 indicated a low cleaning efficiency of the backflushing procedure. The fouling was highly resistant to flow-based cleaning. Additionally, a large amount of biogrowth was observed on the surfaces of submerged stainless steel, steel and aluminum components. It is evident that more frequent backflushing coupled with pressure-based and/or mechanical cleaning is required if the fouling is to be mitigated. High fouling events leading to loss of effectiveness or operability may occur despite appropriate fouling mitigation practices.

C.4 DAMAGE CALCULATIONS

Minor damage to the 0.8 mm wedgewire screen was identified during the October 1, 2019 inspection. Review of the imagery captured during the prior inspections confirmed that the damage occurred between September 18, 2019 and October 1, 2019. The damage is comprised of two distinct compromised sections: widened through slot width on the upstream riverbed facing subsection and missing circumferential wire rings on the downstream riverbed facing subsection. A large amount of plant matter and biogrowth was entangled in the widened slots on the upstream riverbed facing side. The widest portion of the widened slots was clogged by the plant matter and biogrowth. The widest portion of the unclogged widened slots was estimated to be 3.2 mm wide. The missing circumferential wire rings on the downstream riverbed facing subsection were located near the wedgewire screen riser and extended across the bottom 90° of the screen. The widest portion of the missing circumferential wire rings was estimated to be 2.4 mm wide.

A percentage of damaged surface area was calculated using a similar methodology as used for the calculation of clogged surface area. The estimated averages are provided in Table C-3.

Table C-3: 0.8 mm Slot Width Wedgewire Screen Damage Estimation

Subsection	Percentage Damage	Percentage Damage per Side	Total Percentage Damage
Upstream Surface Facing	0%	2%	4%
Upstream Riverbed Facing	4%		
Downstream Surface Facing	0%	6%	
Downstream Riverbed Facing	12%		

The resultant decrease in exclusion efficiency was weighted based on the local decrease in differential pressure. The withdrawal of water through the damaged surface area increases up to an equilibrium where the differential pressure through all portions of the surface area equalizes. Based on the approximate width of the damage, it was assumed that the exclusion efficiency and differential pressure properties of the damaged surface area on the 0.8 mm screen caused it to perform similar to the 3.0 mm wedgewire screen. It was calculated that approximately 8% of the flow rate was withdrawn through the 4% of surface area damaged. There was no damage detected on the 3.0 mm screen.

C.5 CONCLUSION

A significant amount of fouling was observed during the inspection on October 1, 2019. This inspection was scheduled to observe the effectiveness of the backflushing procedure. From the imagery captured during the inspection, backflushing does not seem to be an effective means of maintaining the cleanliness of the screens. A significant amount of fouling remained between the wedgewire screen through slot openings following the backflushing. Furthermore, damage to the 0.8 mm screen occurred on the river facing side. It is uncertain what might have caused the damage.

C.6 INSPECTION IMAGERY

A series of images of each hemispherical subsection of the 3.0 mm wedgewire screen and 0.8 mm wedgewire screen were captured prior to, during and following the backflushing procedure, and is provided in Tables C-4 and C-5, respectively.

Table C-4: 3.0 mm Slot Width Wedgewire Screen Imagery (October 1, 2019 Inspection)

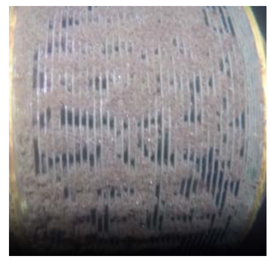
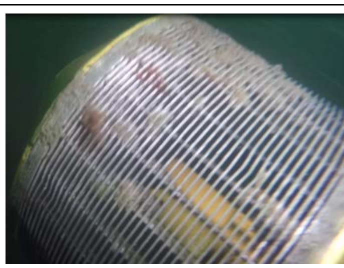
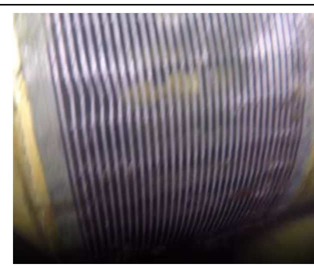
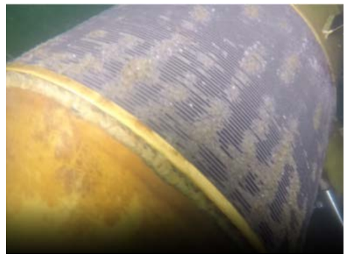
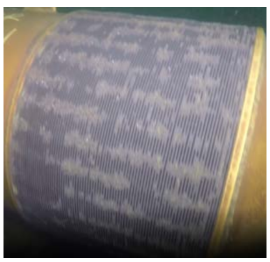
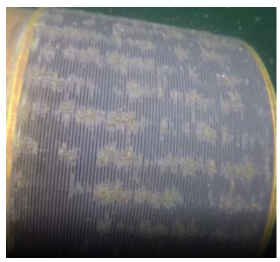
Prior to Backflush	During Backflush	Following Backflush
Upstream Shoreside		
		
Upstream Riverside		
		
Downstream Shoreside		
		
Downstream Riverside		
		

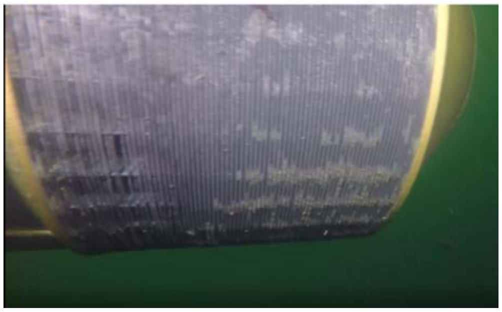
Table C-5: 0.8 mm Slot Width Wedgewire Screen Imagery (October 1, 2019 Inspection)

Prior to Backflush	During Backflush	Following Backflush
Upstream Shoreside		
		
Upstream Riverside		
		
Downstream Shoreside		
		
Downstream Riverside		
		

Images of the damaged subsections of the 0.8 mm wedgewire screen are provided in Table C-6. No equivalent or comparative images of the 3.0 mm wedgewire screen are provided due to the absence of identified damage.

Table C-6: 0.8 mm Slot Width Wedgewire Screen Damage Imagery

(October 1, 2019 Inspection)

Shoreside	Riverside
Upstream Riverbed Facing	
	
Downstream Riverbed Facing	
	

D.0 ADDENDUM D: INCREASED DAMAGE AND FOULING EVENT REPORT

D.1 DESCRIPTION OF ADDENDUM

This addendum was generated following an erratic data reading from the North ADCP equipment that occurred on November 20, 2019. An underwater dive inspection was scheduled for December 7, 2019 to observe and identify the current conditions of the pilot wedgewire screens and equipment. This addendum details the cause of the erratic ADCP data reading, the physical conditions of the pilot wedgewire screens and makes a comparison of the conditions between the October 1, 2019 inspection and the December 7, 2019 inspections. The observed conditions were estimated based on the imagery captured during the underwater inspection.

For clarity, subsections of the pilot wedgewire screens are identified by hemicylinders in reference to the installation configuration as described in Addendum C, Section C.1.

D.2 DESCRIPTION OF INSPECTIONS

On November 20, 2019 an erratic data reading was recorded from the North ADCP equipment. The orientation sensor stated that its position shifted in the water column by approximately 1.5 ft., rotated clockwise by approximately six degrees, and tilted by approximately eight to nine degrees, during a six-minute sampling period. A dive was scheduled for December 7, 2019 to inspect and film equipment conditions. During the inspection, a lobster trap was observed near the North ADCP and is believed to have caused the erratic reading. The ADCP was dragged approximately 30 to 40 ft. from the original installation location and was pinned against the suction hoses. No damage was observed on the ADCP or suction hose. The inspection also observed that the conditions of pilot wedgewire screens had physically deteriorated since the prior inspection on October 1, 2019. While the ADCP was dragged from the specified deployment location, it did not approach either of the pilot wedgewire screens in the process. Post inspection reporting and footage of the underwater inspection demonstrate that during the accidental relocation of the ADCP, the path it was dragged was directly toward the suction hose. Therefore, the damage observed on the screens was not caused by a collision with the ADCP. The imagery shows major damage to the riverbed facing sides and increased fouling on the 0.8 mm screen.

D.3 DAMAGE CALCULATIONS

Previously, the October 1, 2019 dive inspection observed screen damage to be minor and only located on the riverbed facing side of the 0.8 mm screens with a total of 4% of surface area damaged, as shown in Table D-1. The December 7, 2019 dive inspection observed damage on both the 3.0 mm and 0.8 mm pilot wedgewire screens, with a significant increased percentage in the total surface area damaged.

Based on the imagery captured from the inspection, the proportion of damaged surface area was calculated. The calculation for the damaged surface area is similar to the calculation for clogged surface area in Addendum C, Section C.3. Tables D-1 and D-2 detail the damaged surface area for October and December respectively.

The inspection on December 7, 2019 observed major damage to both the 3.0 mm and 0.8 mm screens on the riverbed facing sides. During the previous inspection in October inspection, the 3.0 mm screen did not have any damaged areas. The December inspection observed the development of damaged area on the 3.0 mm screen. The 3.0 mm screen damaged area had widened through slots approximately ¾ in. wide, which increased the percentage of total surface area damaged from 0% to 5.5%. During the October inspection, the damage on the 0.8 mm screens was minor with a few of the through slots being widened to approximately 3.0 mm in width. The damage observed during the December dive inspection revealed a severe increase, including entire sections of the radial rings missing. The smallest damaged opening observed during this December inspection was approximately ¾ in. wide and the largest damaged opening was approximately two inches wide on the 0.8 mm screen. For the 0.8 mm screen, the total surface area damage increased from 4% to 10.25% of total surface area damaged.

Table D-1: Wedgewire Screen Damage Estimation (October 1, 2019 Inspection)

<table>
<tr><th>Subsection</th><th>Percentage Damage</th><th>Percentage Damage per Side</th><th>Total Percentage Damage</th></tr>
<tr><td>3.0 mm Wedgewire screen</td><td>0%</td><td>0%</td><td>0%</td></tr>
<tr><td>0.8 mm Upstream Surface Facing</td><td>0%</td><td rowspan="2">2%</td><td rowspan="4">4%</td></tr>
<tr><td>0.8 mm Upstream Riverbed Facing</td><td>4%</td></tr>
<tr><td>0.8 mm Downstream Surface Facing</td><td>0%</td><td rowspan="2">6%</td></tr>
<tr><td>0.8 mm Downstream Riverbed Facing</td><td>12%</td></tr>
</table>

Table D-2: Wedgewire Screen Damage Estimation (December 7, 2019 Inspection)

<table>
<tr><th>Subsection</th><th>Percentage Damage</th><th>Percentage Damage per Side</th><th>Total Percentage Damage</th></tr>
<tr><td>3.0 mm Upstream Surface Facing</td><td>0%</td><td rowspan="2">3%</td><td rowspan="4">5.5%</td></tr>
<tr><td>3.0 mm Upstream Riverbed Facing</td><td>6%</td></tr>
<tr><td>3.0 mm Downstream Surface Facing</td><td>0%</td><td rowspan="2">8%</td></tr>
<tr><td>3.0 mm Downstream Riverbed Facing</td><td>16%</td></tr>
<tr><td>0.8 mm Upstream Surface Facing</td><td>0%</td><td rowspan="2">3%</td><td rowspan="4">10.25%</td></tr>
<tr><td>0.8 mm Upstream Riverbed Facing</td><td>6%</td></tr>
<tr><td>0.8 mm Downstream Surface Facing</td><td>0%</td><td rowspan="2">17.5%</td></tr>
<tr><td>0.8 mm Downstream Riverbed Facing</td><td>35%</td></tr>
</table>

The resultant decrease in exclusion efficiency was weighted based on the local decrease in differential pressure. The withdrawal of water through the damaged surface area increases up to an equilibrium where the differential pressure through all portions of the surface area equalizes. Based on the approximate width of the damage, it is assumed that the exclusion efficiency and differential pressure properties of the damaged surface area performs as an open hole in the pilot wedgewire screens. It was calculated that approximately 8.6% of the flow rate is withdrawn through the 5.5% of damaged surface area for the 3.0 mm screen and approximately 27.7% of the flow rate is withdrawn through the 10.25% of damaged surface area for the 0.8 mm screen.

D.4 FOULING CALCULATIONS

Fouling conditions changed since the previous dive inspection on October 1, 2019. From the October inspection, the total clogged surface area was 21% for both screens. During the December inspection, the clogged surface area decreased on the 3.0 mm screen from 21% to 17% but had increased on the 0.8 mm screen from 21% to 37%.

A percentage of clogged surface area was calculated using the methodology used for the calculation in Addendum C, Section C.3. Tables D-3 and D-4 below detail the clogged surface area from the October inspection and the December inspection, respectively.

Table D-3: Wedgewire Screen Fouling Estimation (October 1, 2019)

<table>
<tr><th>Subsection</th><th>Percentage Clogged</th><th>Percentage Clogged per Side</th><th>Total Percentage Clogged</th></tr>
<tr><td>3.0 mm Upstream Shoreside</td><td>2%</td><td rowspan="2">34%</td><td rowspan="4">21%</td></tr>
<tr><td>3.0 mm Upstream Riverside</td><td>66%</td></tr>
<tr><td>3.0 mm Downstream Shoreside</td><td>10%</td><td rowspan="2">8%</td></tr>
<tr><td>3.0 mm Downstream Riverside</td><td>6%</td></tr>
<tr><td>0.8 mm Upstream Shoreside</td><td>14%</td><td rowspan="2">19%</td><td rowspan="4">21%</td></tr>
<tr><td>0.8 mm Upstream Riverside</td><td>24%</td></tr>
<tr><td>0.8 mm Downstream Shoreside</td><td>14%</td><td rowspan="2">22%</td></tr>
<tr><td>0.8 mm Downstream Riverside</td><td>30%</td></tr>
</table>

Table D-4: Wedgewire Screen Fouling Estimation (December 7, 2019)

<table>
<tr><th>Subsection</th><th>Percentage Clogged</th><th>Percentage Clogged per Side</th><th>Total Percentage Clogged</th></tr>
<tr><td>3.0 mm Upstream Shoreside</td><td>2%</td><td rowspan="2">24%</td><td rowspan="4">17%</td></tr>
<tr><td>3.0 mm Upstream Riverside</td><td>46%</td></tr>
<tr><td>3.0 mm Downstream Shoreside</td><td>12%</td><td rowspan="2">11%</td></tr>
<tr><td>3.0 mm Downstream Riverside</td><td>10%</td></tr>
<tr><td>0.8 mm Upstream Shoreside</td><td>20%</td><td rowspan="2">37%</td><td rowspan="4">36%</td></tr>
<tr><td>0.8 mm Upstream Riverside</td><td>55%</td></tr>
<tr><td>0.8 mm Downstream Shoreside</td><td>35%</td><td rowspan="2">35%</td></tr>
<tr><td>0.8 mm Downstream Riverside</td><td>35%</td></tr>
</table>

D.5 CONCLUSIONS

A significant amount of damage was observed during the inspection on December 7, 2019. This inspection was scheduled as a result of an erratic reading from the ADCP equipment, which then observed that the screens had physically deteriorated since the previous inspection from October 2019. The screens had major damage and continued to have clogged surface areas. Damage to the 3.0 mm screen was similar to the damage that was first observed on the 0.8 mm screens, indicating the deterioration of the screens occurred through a similar mechanism and was not circumstantial to a singular occurrence. The damage on the 0.8 mm screen had radial Z-Alloy rings sections missing in the damaged areas and had accumulated fouling on the screen. From the damage observed during the inspections, it is anticipated that the physical conditions of the screens would have continued to deteriorate and eventually would have led to decreased effectiveness of the screens. Similar deterioration would be expected with a full-scale screen installation.

D.6 INSPECTION IMAGERY

Below is an imagery comparison of past to current conditions for the pilot wedgewire screens. Imagery of the ADCP inspection is also included below.

Table D-5: Slot Width Wedgewire Screen Damage Imagery Comparison

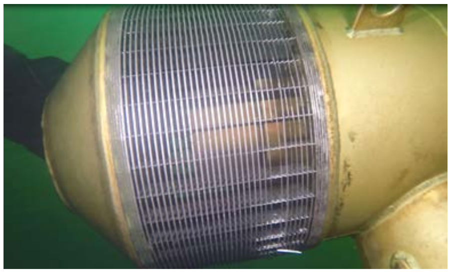
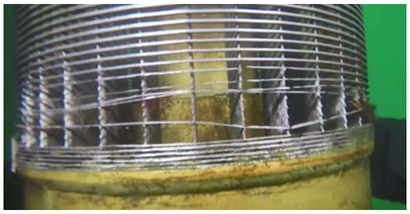
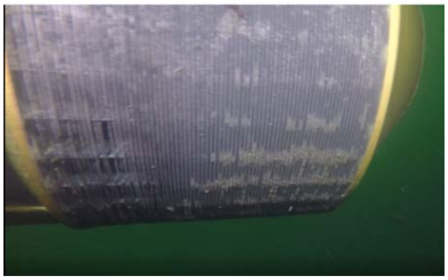
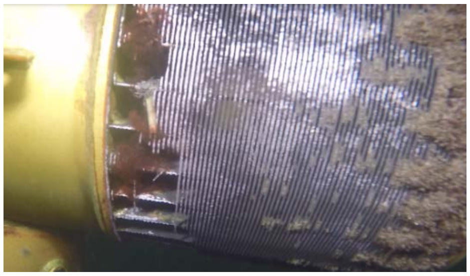
October 1, 2019	December 7, 2019
Upstream 3.0 mm Wedgewire Screen Riverbed Facing Damage	
No damage was observed on the 3.0 mm screens during the October inspection.	
Downstream 3.0 mm Wedgewire Screen Riverbed Facing Damage	
No damage was observed on the 3.0 mm screens during the October inspection.	
Upstream 0.8 mm Wedgewire Screen Riverbed Facing Damage	
	
Downstream 0.8 mm Wedgewire Screen Riverbed Facing Damage	
	

Table D-6: 3.0 mm Slot Width Fouling Imagery Comparison

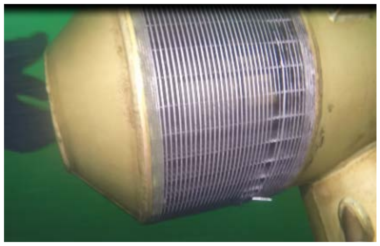
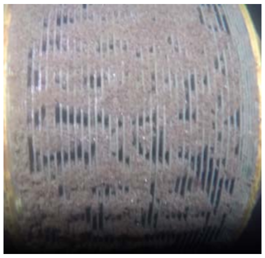
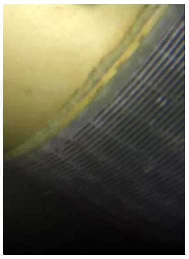
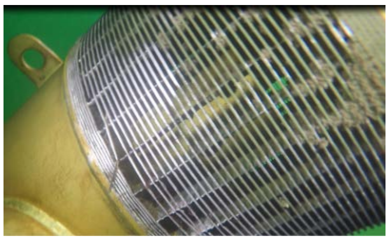
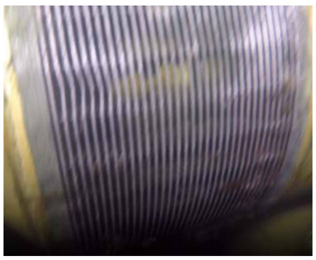
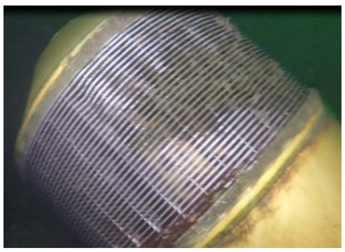
October 1, 2019 Inspection	December 7, 2019 Inspection
Upstream Shoreside	
	
Upstream Riverside	
	
Downstream Shoreside	
	
Downstream Riverside	
	

Table D-7: 0.8 mm Slot Width Fouling Imagery Comparison

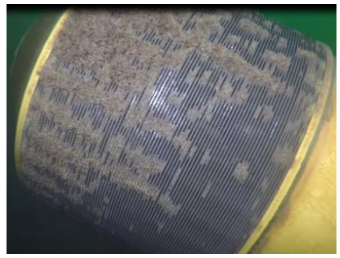
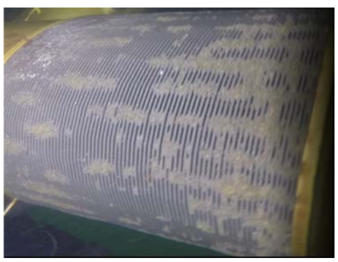
October 1, 2019	December 7, 2019
Upstream Shoreside	
	
Upstream Riverside	
	
Downstream Shoreside	
	
Downstream Riverside	
	

Table D-8: North ADCP Inspection

North ADCP Against Suction Hose

North ADCP Returned to Location

Lobster Trap Against Suction Hose


E.0 ADDENDUM E: FINAL DAMAGE AND FOULING

E.1 DESCRIPTION OF ADDENDUM

This addendum was generated following the series of underwater inspections for the Wedgewire Screen Site-Specific Study at GSP's Schiller Station. Following a series of events that impacted the effectiveness of the pilot wedgewire screens, video and photo images were used to keep a record of the physical conditions of the screens. The inspections generated an imagery comparison of the damaged surface area and clogged surface area between October 1, 2019 and January 23, 2020. The physical conditions of the screens rapidly degraded between the inspection periods, and as a result, reduced the entrainment reduction effectiveness of the pilot wedgewire screens. Percentages of the total damaged area and percentage of the clogged surface area are detailed in Table E-1. This addendum also details the conditions of the pilot wedgewire screens at each inspection, as shown in Table E-2.

For clarity, subsections of the pilot wedgewire screens are identified by hemicylinders in reference to the installation configuration. The naming convention of the wedgewire screen subsections used in this Addendum follow the configuration provided in Figure C.1 of Addendum C.

E.2 DESCRIPTION OF INSPECTIONS

The inspections of the screens occurred on an as-needed basis and were prompted according to the observations of the site operators. The inspection on October 1, 2019 occurred in order to record the physical condition of the pilot wedgewire screens during a backflushing event, as detailed in Addendum C. The inspection on December 7, 2019 occurred in response to an abnormal reading from the ADCP, as detailed in Addendum D. The onshore inspection on January 23, 2020 occurred at the conclusion of the study period and recorded the final physical condition of the pilot wedgewire screens.

E.3 DESCRIPTION OF IMAGERY

The final inspection images were captured onshore shortly after the removal of the pilot wedgewire screens on January 23, 2020. The images captured were used to document and compare the physical deterioration of the pilot wedgewire screens over the study period. Since the prior inspection from December 7, 2019, the physical condition of the screens rapidly deteriorated. The amount of clogged surface area visible in the imagery demonstrates the fouling that has compounded during the study period.

E.4 DAMAGE COMPARISON

The methodology used for calculating the damaged surface area is similar to the methodology used for calculating the clogged surface area as described in Section C.3 of Addendum C. The proportion of damaged surface area of the 3.0 mm screen increased to 15.5%. The proportion of damaged surface area of the 0.8 mm screen at the conclusion of the testing period increased to 19.25%. The damage is localized on the riverbed facing sides but increased in severity with large portions of the screens missing. The damaged areas measure as wide as 2.5 in. on the 3.0 mm screens and as wide as 3.5 in. on the 0.8 mm screens. Table E-8 shows imagery of the screens compared alongside a measuring tape. With the amount of damage, the screens have a decreased entrainment reduction effectiveness. Table E-1 details the damaged surface area of the screens at the conclusion of the study period. Due to the size of the damaged portion of the screens, the differential pressure boundary was approximated as an open hole. This had an effect on the withdrawal profile of the screens. There was a larger proportionate withdrawal flow rate through the damaged areas due to the larger openings. The withdrawal flow rate through the damaged portions on the 3.0 mm screen increased to 23% by the conclusion of the testing period. The withdrawal flow rate through the damaged portions increased on the 0.8 mm screen to 44.5% by the conclusion of the testing period. The total damaged area has a withdrawal flow rate that increased proportionally with the increase of damaged area during the testing period. Table E-2 shows the increase of damaged surface area and withdrawal flow rates through the damaged surface areas across the three inspections.

Table E-1: Wedgewire Screen Damage Estimation (January 2020 Inspection)

Subsection	Percentage Damage	Percentage Damage per Side	Total Percentage Damage
3.0 mm Upstream Surface Facing	0%	17.5%	15.5%
3.0 mm Upstream Riverbed Facing	35%		
3.0 mm Downstream Surface Facing	0%	13.5%	
3.0 mm Downstream Riverbed Facing	27%		
0.8 mm Upstream Surface Facing	0%	18.5%	19.25%
0.8 mm Upstream Riverbed Facing	37%		
0.8 mm Downstream Surface Facing	0%	20%	
0.8 mm Downstream Riverbed Facing	40%		

Table E-2: Wedgewire Screen Damage Estimation Comparison

Screen	October 1, 2019		December 7, 2019		January 23, 2020	
	Damaged Area	Withdraw Flow Rate	Damaged Area	Withdraw Flow Rate	Damaged Area	Withdraw Flow Rate
3.0 mm	0%	0%	5.5%	8.6%	15.5%	23%
0.8 mm	4%	8%	10.25%	27.7%	19.25%	44.5%

E.5 FOULING COMPARISON

The inspection imagery provides a record of the clogged surface area. The calculation for the clogged surface area is detailed in Addendum C, Section C.3. During the final onshore inspection, it was noted that significant fouling continued to occur. The amount and distribution of clogged surface area remained persistent throughout the inspections. The final amount of surface area is approximate due to some amount of fouling being removed during the screen retrieval process. Table E-3 shows the percentage of the covered surface area during the final inspection and Table E-4 compares the percentage of clogged surface area throughout the testing period.

Table E-3: Wedgewire Screen Fouling Estimation (January 23, 2020)

Subsection	Percentage Clogged	Percentage Clogged per Side	Total Percentage Clogged
3.0 mm Upstream Shoreside	2%	17%	14.5%
3.0 mm Upstream Riverside	15%		
3.0 mm Downstream Shoreside	7%	12%	
3.0 mm Downstream Riverside	5%		
0.8 mm Upstream Shoreside	16%	33%	31.5%
0.8 mm Upstream Riverside	50%		
0.8 mm Downstream Shoreside	30%	30%	
0.8 mm Downstream Riverside	30%		

Table E-4: Wedgewire Screen Fouling Estimation Comparison

Screen	Fouling Percentage October 1, 2019	Fouling Percentage December 7, 2019	Fouling Percentage January 23, 2020
3.0 mm	21%	17%	14.5%*
0.8 mm	21%	36%	31.5%*

* an amount of fouling was removed during the screen retrieval process

E.6 CONCLUSION

The final onshore inspection concluded the testing period for the Wedgewire Screen Site-Specific Study at GSP's Schiller Station. The inspection was used to outline a final comparison of the physical conditions of the pilot wedgewire screens. Throughout the testing period, images of the pilot wedgewire screens captured and recorded the percentage of damaged surface area and the percentage of clogged surface area between the months of October 2019 and January 2020. The pilot wedgewire screens had a rapid deterioration rate in the waters of the Piscataqua River adjacent to Schiller Station over the duration of the study period. Additionally, the biogrowth was observed to thicken throughout the duration of the testing period. For both of the pilot wedgewire screens the percentage of damaged surface area also quickly increased during the inspection period. The cause of the damage is not verified. Given the observed damage and fouling on both pilot wedgewire screens, it is believed that the issues were not circumstantial to the site-specific study. The amount of consistent damage and fouling on both screens indicates that similar damage on a full-scale screen would occur, furthermore it has been seen that once damage occurs the physical conditions of the screens rapidly deteriorate. At the conclusion of the testing period, the pilot wedgewire screens were considered to be in an ineffective and unusable condition. Due to the rapid deterioration of the screens, the implementation of this technology is not recommended.

E.7 COMPARISON OF IMAGERY

Table E-5: Wedgewire Screen Damage Imagery Comparison

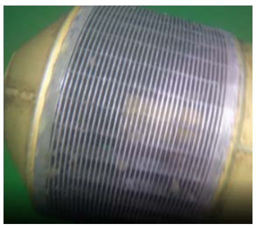
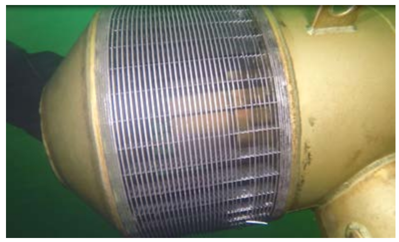
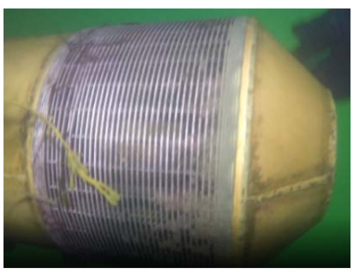
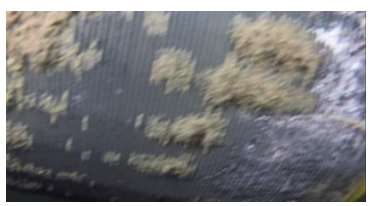
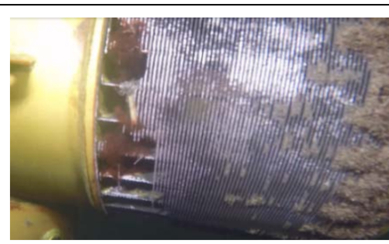
October 1, 2019	**December 7, 2019**	**On Shore January 23, 2020**
Upstream 3.0 mm Wedgewire Screen River Facing Damage		
		
Downstream 3.0 mm Wedgewire Screen River Facing Damage		
		
Upstream 0.8 mm Wedgewire Screen River Facing Damage		
		
Downstream 0.8 mm Wedgewire Screen River Facing Damage		
		

Table E-6: 3.0 mm Slot Width Wedgewire Screen Fouling Imagery Comparison

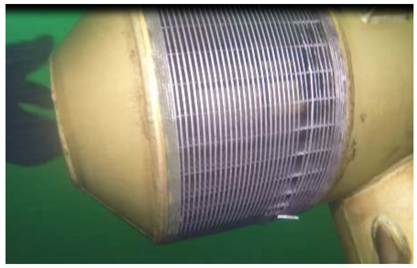
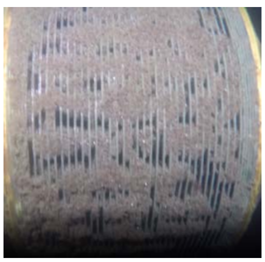
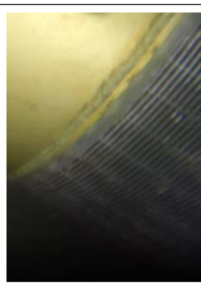
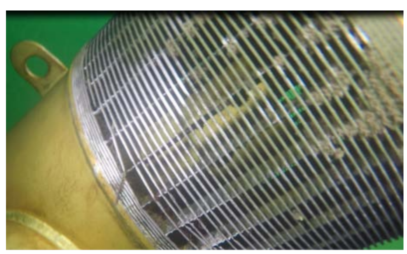
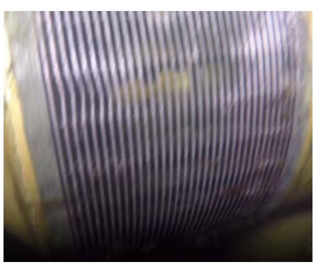
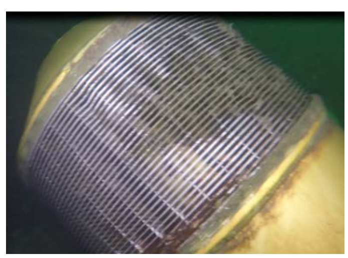
October 1, 2019	December 7, 2019	On Shore January 23, 2020
Upstream Shoreside		
		
Upstream Riverside		
		
Downstream Shoreside		
		
Downstream Riverside		
		

Table E-7: 0.8 mm Slot Width Wedgewire Screen Fouling Imagery Comparison

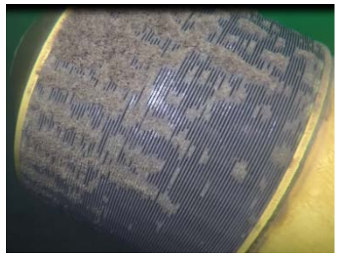
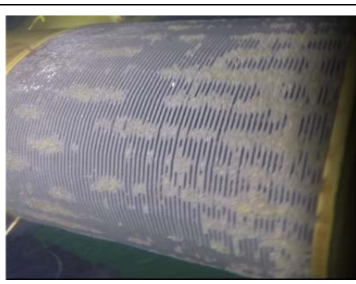
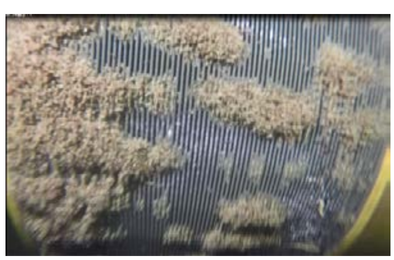
October 1, 2019	December 7, 2019	On Shore January 23, 2020
Upstream Shoreside		
		
Upstream Riverside		
		
Downstream Shoreside		
		
Downstream Riverside		
		

Table E-8: Imagery of Measured Damage on Pilot Wedgewire Screens

3.0 mm Screen Damage	0.8 mm Screen Damage
	

Schiller Station Wedgewire Screen Site-Specific Study Technical Availability Summary

This technical availability summary documents the condition and performance of the pilot wedgewire screens at Schiller Station and provides conclusions regarding the availability of a full-scale installation. The conditions of the pilot wedgewire screens were quantified over time using imagery from underwater dive inspections. A significant amount of fouling and damage to the pilot wedgewire screens was observed during the approximate yearlong test period of continuous operation. The characteristics observed during the in-situ testing period are considered representative of what should be expected from a full-scale installation of this wedgewire screen technology.

The amount and quality of observed fouling and damage to the pilot wedgewire screens suggests that maintenance of year-round operability of a full-scale installation of wedgewire screens at Schiller Station would impose significant technical challenges. The installation of an active air burst system is typically recommended to assist the removal of fouling like the kind observed during the period dive inspections on a regular frequency. However, due to the inability to remove fouling deposits from the wedgewire screen using backflushing procedures and moderate buffing, the effectiveness of an active air burst system is questionable. At a minimum, an annual inspection and mechanical cleaning of the wedgewire screens would be needed prior to the peak entrainment season to ensure proper screen functionality. More frequent inspections and mechanical cleaning would also be required, based on operating practices and unforeseen fouling events. Frequent scheduled or emergent inspections and cleanings may result in a high maintenance cost to support the continued operation of a full-scale installation of wedgewire screens.

Ambient (i.e. water quality induced) and/or flow-based (i.e. constant sweeping/through velocity induced) corrosion could cause further damage to the screens. No feasible, additional mitigation of corrosion has been identified beyond the measures taken during the pilot test. When significant damage is identified during inspections, repair of the screens (either in water or onshore) would be required to maintain the exclusion efficiency of the wedgewire screens. Reduced effectiveness of the wedgewire screens due to unidentified damage could be present for extended periods of time between inspections. Repair or replacement of the wedgewire screens would be an expensive and time intensive task which could occur frequently based on the conditions observed during the site-specific study.

A bypass system would be imperative to ensure continued reliability during wedgewire screen fouling events. Use of the bypass system would result in extended periods when the wedgewire screens would be removed from service and provide no protection. The duration and timing of these periods is currently unknown. Use of a bypass system would be required during the repair process for continued withdrawal of cooling water. If the wedgewire screens are damaged, they would operate at decreased exclusion efficiency.

The fouling and damage to the pilot wedgewire screens during the approximate 12 months of operation present critical concerns that would challenge the operability of a full-scale installation of wedgewire screens at Schiller Station. Implementation of a full-scale installation of wedgewire screens would be at risk of significant fouling, loss of effectiveness, and catastrophic failure. Given the results of the testing period, the incorporation of additional design features to reduce the potential for fouling and impact-based damage would need to be considered prior to full-scale installation of wedgewire screens at Schiller Station. Even then, the effectiveness of any such design features is currently unknown. Fouling and damage commensurate with the conditions observed during the testing period would result in operational challenges, increased maintenance requirements, and routine unavailability of the system. The availability and effectiveness of a full-scale installation of wedgewire screens would be uncertain and unreliable. For these reasons, it is concluded that wedgewire screens capable of operating continuously and reliably at Schiller Station are not available. Installation of wedgewire screens at Schiller Station would be a difficult, costly and imprudent measure which would not provide reliable, year-round operation.